Pew Research Center

FOR RELEASE OCTOBER 28, 2019

Experts Optimistic About the Next 50 Years of Digital Life

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RECOMMENDED CITATION

Pew Research Center, October 2019, "Experts Optimistic About the Next 50 Years of Digital Life"

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Experts Are Optimistic About the Next 50 Years of Life Online

Fifty years after the first computer network was connected, most experts say digital life will mostly change humans' existence for the better over the next 50 years. However, they warn this will happen only if people embrace reforms allowing better cooperation, security, basic rights and economic fairness

The year 1969 was a pivot point in culture, science and technology. On Jan. 30, the Beatles played their last show. On July 20, the world watched in awe as Neil Armstrong and Edwin "Buzz" Aldrin become the first humans to walk on the moon. Less than a month later, nearly half a million music fans overran a muddy field near Woodstock, New York, for what Rolling Stone calls the "greatest rock festival ever."

But the 1969 event that had the greatest global impact on future generations occurred with little fanfare on Oct. 29, when a team of UCLA graduate students led by professor Leonard Kleinrock connected computer-to-computer with a team at the Stanford Research Institute. It was the first host-to-host communication of ARPANET, the early packet-switching network that was the precursor to today's multibillion-host internet.

Heading into the network's 50th anniversary, Pew Research Center and Elon University's Imagining the Internet Center asked hundreds of technology experts, including Kleinrock and fellow internet pioneers, how individuals' lives might be affected by the evolution of the internet over the next 50 years. Overall, 530 technology pioneers, innovators, developers, business and policy leaders, researchers and activists in the nonscientific canvassing responded to this query:

> ***The year 2019 will mark the 50th anniversary of the first host-to-host internet connection. Please think about the next 50 years. Where will the internet and digital life be a half century from now?*** *Please tell us how you think connected technology, platforms and applications will be integrated into people's lives. You can tackle any dimension of this question that matters to you. You might consider focusing on questions like this: What changes do you expect to see in the digital world's platform companies? What changes do you expect to see in the apps and features that will ride on the internet? How will digital tools be integrated into everyday life? What will be entirely new? What will evolve and be recognizable from today's internet? What new rules, laws or innovations in its engineering over the intervening years will change the character of today's internet?*

Considering what you just wrote about your expectations for the next 50 years, how will individuals' lives be affected by the changes you foresee?

Some **72%** of these respondents say there would be *change for the better,* **25%** say there would be *change for the worse* and **3%** believe there would be *no significant change.*

This is a non-scientific canvassing based on a non-random sample. Thus, the results are not projectable to any population other than the individuals expressing their points of view in this sample. The respondents' remarks reflect their personal positions and are not the positions of their employers.

The optimists responding to the better-worse-no change question expressed hope that in the next 50 years digital advances will lead to longer lifespans, greater leisure, more equitable distributions of wealth and power and other possibilities to enhance human well-being. At the same time, nearly all of these experts' written predictions included warnings about the possibilities of greater surveillance and data-abuse practices by corporations and governments, porous security for digitally connected systems and the prospect of greater economic inequality and digital divides unless policy solutions push societies in different directions.

In short, these experts argue the future is up for grabs and some argue key decisions need to be made soon. The main themes in these hundreds of experts' comments are outlined in this table.

Themes about the next 50 years of life online

CREATING A FAIR AND EQUITABLE DIGITAL FUTURE	Humanity's responsibility	Digital life will continue to be what people make of it. For a better future, humans must make responsible decisions about their partnership with technology.
	Public policy and regulation	The age of a mostly unregulated internet will come to an end. Elected officials and technology leaders will move ahead with regulatory frameworks aimed at protecting the public good. The lawless alternative has caused dangerous disruptions across society.
	Internet of everything	In 50 years, internet use will be nearly as pervasive and necessary as oxygen. Seamless connectivity will be the norm, and it may be impossible to unplug.
	Visions of the future	From amazing advancements to dystopian developments, experts imagine a wide array of possible scenarios for the world 50 years in the future.
HOPEFUL VISIONS OF 2069	Living longer and feeling better	Internet-enabled technology will help people live longer and healthier lives. Scientific advances will continue to blur the line between human and machine.
	Less work, more leisure	Artificial Intelligence (AI) tools will take over repetitive, unsafe and physically taxing labor, leaving humans with more time for leisure.

	Individualized experiences	Digital life will be tailored to each user.
	Collaboration and community	A fully networked world will enhance opportunities for global collaboration, cooperation and community development, unhindered by distance, language or time.
	Power by the people	Expanded internet access could lead to further disruption of existing social and political power structures, potentially reducing inequality and empowering individuals.
WORRISOME VISIONS OF 2069	Widening divides	The divide between haves and have-nots will grow as a privileged few hoard the economic, health and educational benefits of digital expansion.
	Internetenabled oppression	A powerful elite will control the internet and use it to monitor and manipulate, while providing entertainment that keeps the masses distracted and complacent.
	Connected and alone	The hyperconnected future will be populated by isolated users unable to form and maintain unmediated human relationships.
	The end of privacy	Personal privacy will be an archaic, outdated concept, as humans willingly trade discretion for improved healthcare, entertainment opportunities and promises of security.
	Misallocated trust	Digital life lays you bare. It can inspire a loss of trust, often earns too much trust and regularly requires that you take the plunge even though you have absolutely no trust.
	"There is no planet B"	The future of humanity is inextricably connected to the future of the natural world. Without drastic measures to reduce environmental degradation, the very existence of human life in 50 years is in question.

PEW RESEARCH CENTER and ELON UNIVERSITY'S IMAGINING THE INTERNET CENTER, 2019

Among the experts making the case that choices made now could affect whether the future turns out well or not was **Erik Brynjolfsson**, director of the MIT Initiative on the Digital Economy and author of "Machine, Platform, Crowd: Harnessing Our Digital Future." He wrote, "I don't think the right framing is 'will the outcome be good, or bad?' but rather it must be 'how will we shape the outcome, which is currently indeterminate?' I'm hopeful that we will make the right choices, but only if we realize that the good outcomes are not at all inevitable."

Others echoed this point. **David Bray**, executive director for the People-Centered Internet coalition, commented, "There will be a series of disruptions to our current way of living and whether we, as humans, navigate them successfully for the benefit of all or, unfortunately, just a few, remains to be seen…. What we are seeing is an increasing affordability and availability of technologies that only were available to large nation-states 20 years ago. The commercial sector now outpaces the technology development of nation-states, which means groups can have advanced disruptive technologies that can be used for good or bad [and] that can massively impact global events. This trend will continue and will challenge the absorptive capacity of societies to keep up with such technology developments. No longer do we have five to 10 years to assess the impact of a technology and then incorporate norms, laws, etc. Now we have to operate on a

sixmonth or three-month time horizon which, when combined with the media's tendency to dramatically oversimplify news and reduce complications in narratives about what is occurring, risks oversimplifying for the public the issues at hand, polarizing different groups and creating an ever-increasing number of 'wedge issues' in societies."

Esther Dyson, entrepreneur, former journalist, founding chair at ICANN and founder of Wellville, wrote, "The impact of the internet is not entirely inherent in the technology; it depends on what we do with it. It's so powerful that it has given us the opportunity to satisfy many of our short-term desires instantly; we need to learn how to think longer-term. So far we have mostly done a bad job of that: Individuals are addicted to short-term pleasures such as likes and other acknowledgments (to say nothing of drugs and instantly available, online-ordered pleasures), to finding friends rather than building friendships (and marriages); businesses to boosting quarterly profits and to recruiting 'stars' rather than investing in their own people; nonprofits to running programs rather than building institutions; and politicians to votes and power. Do we have the collective wisdom to educate the next generation to do better despite our own poor example?"

Susan Etlinger, an industry analyst for Altimeter Group and expert in data, analytics and digital strategy, commented, "In 50 years, what we know as our internet will be largely obsolete. Rather than organizing information in the form of URLs, apps and websites, our digital interactions will be conversational, haptic and embedded in the world we live in (even, to some extent, in ourselves). As a result, the distinction between the physical and digital worlds will largely fall away. Prosthetics, imaging, disease and pathogen detection, and brain science (identifying, understanding and perhaps even modifying the workings of the brain) will all see advances far beyond what we can imagine today. Our ability to understand weather and the natural world at scale will be immensely powerful, driven by advances in machine intelligence and networking. Yet all of these innovations will mean little if the algorithms and technology used to develop them are not applied with the same attention to human consequences as they are to innovation. Even today, the 'Minority Report' notion of 'pre-crime' is crudely possible using predictive policing technology, yet it is just one example of how embedded bias can perpetuate and actually intensify injustice. This is also true in education, health care, our financial system, politics and really every system that uses data to generate predictions about the world and the future. This is not at all to say that we should retreat, but rather that we should embrace the opportunity intelligent technologies give us – to see and better understand our biases so we can optimize for the world we want, rather than a more efficient version of the world we already have. We've already seen this capability weaponized in the political sphere; the decisions we make now will set a precedent for whether we are able to use intelligent technologies justly and ethically, or whether in 50 years we have consigned ourselves to a permanent state of information (and literal) warfare."

Lindsey Andersen, an activist at the intersection of human rights and technology for Freedom House and Internews, now doing graduate research at Princeton University, commented, "The net benefits for people, in access to government services, information and quality of life, will outweigh the net losses. That said, as with any major advancement, there will be winners and losers. The losses will likely come in the form of jobs, autonomy and even freedom. But, perhaps for the first time, we are in a position to mitigate these losses because we can predict them. And if we begin solving the problems we have with technology today, it will help address the problems of the future."

Alex Halavais, an associate professor of social technologies at Arizona State University, wrote, "The development and diffusion of new technologies have had a net-positive effect on our society over time. Certainly, there have been several near-cataclysmic events over the last two 50-year cycles, and we are currently undergoing the slow-moving technologically motivated disaster of the anthropocene. But over time these technologies have helped to enable more freedom than oppression, more abundance than deprivation and more creation than destruction. I would bet on that future."

Fiona Kerr, industry professor of neural and systems complexity at the University of Adelaide, commented, "People love bright, shiny things. We adopt them quickly and then work out the disadvantages, slowly, often prioritizing on litigious risk. The internet has been a wonderful summary of the best and worst of human development and adoption – making us a strange mixture of connected and disconnected, informed and funneled, engaged and isolated, as we learn to design and use multipurpose platforms shaped for an attention economy."

Joly MacFie, president of the Internet Society's New York Chapter, said, "We are still in digital society's adolescence. Maturity will bring ubiquity, understanding, utility, security and robustness."

Randy Marchany, chief information security officer at Virginia Tech and director of Virginia Tech's IT Security Laboratory, said, "The human-machine interface will be where I think we'll see the biggest change. In the beginning, keyboard-based devices were the primary way of communicating with a computer. Today, natural-language devices (Watson, Alexa, Siri) are becoming the norm. The younger generations are using more and more conversational methods to communicate with their devices. Descendants of the Google Glass-style devices displaying info using augmented reality techniques will become the normal way of accessing and inputting information. I suspect that governments will find themselves at odds with the corporations that collect this data. For example, if Facebook can influence an election, does a government fear it, partner with it, or take it over completely? Technology will create societal disruptions a la previous 'industrial revolutions' as older technologies and their jobs disappear, and the workforce needs to

be trained in the new technologies. This disruption will cause fundamental changes in governments, attitudes and way of life. There will be a polarization of views between the new tech and old tech worlds. How we deal with this polarization will determine whether the transition is peaceful or not."

Richard Forno, of the Center for Cybersecurity and Cybersecurity Graduate Program at the University of Maryland-Baltimore County, wrote, "A few thoughts: 1) I see the future internet as more commercialized and locked-down in response to corporate/government interests over IP controls, cybersecurity and perhaps public discourse – to include enacting national borders in cyberspace. 2) Continued Balkanization of the future internet as people embrace various new tech – which Internet of Things platform will they use? Which 'smart'-whatever platform will become dominant? Will we have many separate ecosystems with as-yet undefined lifespans and/or vendor support cycles that lead to forced upgrades? What problems will that pose? 3) Current questions raised over how internet tech like social media, mobile devices, everything-on-demand impacts society may well set the stage for radical rethinking about what the future internet will look like – and I suspect it'll be far removed from the romantic 'informational equality' of the 1990s and early 2000s. The bottom line: The future internet will reflect future humankind. Humans are a chaotic and fallible species – so how we will develop/embrace future tech within our global society is not something easily predicted other than to say it will reflect contemporary views, mores and interests."

John McNutt, a professor in the school of public policy and administration at the University of Delaware, responded, "Not every technology is a good idea, and every advance should be carefully considered in terms of its consequence. On balance, technology has made much human progress possible. This is likely to continue. We will always have false starts and bad ideas. People will misuse technology, sometimes in horrific ways. In the end, human progress is based on creating a future underpinned by knowledge, not ignorance."

1. Themes about the next 50 years of life online

When the 530 participants in this study shared wide-ranging insights about the future, most of their responses were tied to hopes and concerns over human evolution in light of technological change. A share of their comments referred to technological advances such as brain-computer interfaces, virtual immersive experiences that will teach and entertain users, pervasive connectivity linked to artificial intelligence (AI) that helps people navigate the world and understand it better and predictive, and personalized applications that make life easier and more enjoyable. A few predicted space-based interactions.

The respondents pushed for an array of reforms in laws, international treaties, technology systems and educational processes to try to lessen the known harms that digital technologies already create.

The next sections of this report briefly describe the most common themes from respondents and include remarks by Internet Hall of Fame members and other internet pioneers. After that, several additional chapters cover the broad theses of hundreds of other responses, bunched into broad categories. Some answers have been lightly edited for clarity.

Creating a fair and equitable digital future

Theme 1: Humanity's responsibility. Digital life will continue to be what people make of it. For a better future, humans must make responsible decisions about their partnership with technology.

Responses representing this theme:

Ben Shneiderman, distinguished professor and founder of the Human Computer Interaction Lab at University of Maryland, said, "The future will be shaped by those who understand how to support trust, empathy, responsibility and privacy. Ever richer layers of social systems will support community building, political action and commercial opportunities. Medical systems that collect patient data will give richer portraits of individual health as well as data to develop new treatment protocols. Persuasion to improve patient wellness will enhance compliance with health regimes, as measured by quantified-self tools that allow patients to monitor their health."

Bill Woodcock, executive director at Packet Clearing House, the research organization behind global network development, commented, "The technological changes that matter are the ones that allow people to live safe and pleasant lives, pursuing intellectual challenge and pleasure, rather than simply trying to stay alive.… But that's not how they're being used right now. Right now they're largely being used to exploit human psychological weaknesses for very short-term gains for a very few people, and any benefits the rest of the world derives along the way exist

merely to sweeten the pot. This is a consequence of combining unbridled capitalism with technology in the absence of empathetic humanity or public responsibility."

David Zubrow, associate director of empirical research at the Carnegie Mellon Software Engineering Institute, said, "The trend of digital assistants that learn your preferences and habits from all the devices that you interact with will become integrated with each other and take on a persona. They may even act on your behalf with a degree of independence in the digital and physical worlds. As AI advances and becomes more independent and the internet becomes the world in which people live and work, laws for responsibility and accountability of the actions of AI will need to be made."

Theme 2: Public policy and regulation. The age of a mostly unregulated internet will come to an end. Elected officials and technology leaders will move ahead with regulatory frameworks aimed at protecting the public good. The lawless alternative has caused dangerous disruptions across society.

Responses representing this theme:

Angelique Hedberg, senior corporate strategy analyst at RTI International, said, "The definition of what it means to be human will evolve and the laws and regulation will follow, albeit in a less than direct manner. We will value governments in new and different ways, and we will expect more from our technology platforms. The deluge of data will provide new inputs into the decision models for platforms, bringing greater clarity to the short-term benefits and long-term risks, in return making the financial decisions more social, environmental and moral. Where laws and regulations can [articulate] a bottom line, they will. Where law and regulations cannot, the planet will step in and regulate the excess."

Adam Popescu, a writer who contributes frequently to the New York Times, Washington Post, Bloomberg Businessweek, Vanity Fair and the BBC, wrote, "The dark side of the web has emerged, and it's come bringing the all-too-human conditions the web's wunderkinds claimed they would stamp out. Given the direction in the last five years, the weaponization of the web, it will go more and more in this direction, which ultimately means regulation and serious change from what it is now."

Micah Altman, a senior fellow at the Brookings Institution and head scientist in the program on information science at MIT Libraries, said, "How technology affects people and society depends in large part on what values we embed into the design of these technologies, and who controls them. With appropriate governance, information, communication and AI, technologies can vastly increase human capability if we as a society establish the rights of users of ubiquitous technologies to inspect their operation, audit their results and exercise agency into how these systems interact

with them and their data, and if we use effective regulation to ensure that these systems are both designed and operated to preserve these rights. If not, it is likely that these increasingly powerful technologies will enable concentrations of power and influence over others – economically through using these technologies to amplify the advantage of wealth, through influence over beliefs and persuasion, and through surveillance and coercion. I choose to be hopeful."

Theme 3: Internet of everything. In 50 years, internet use will be nearly as pervasive and necessary as oxygen. Seamless connectivity will be the norm, and it may be impossible to unplug.

Responses representing this theme:

Bebo White, managing editor of the Journal of Web Engineering and emeritus associate of the SLAC National Accelerator Laboratory, said, "The internet as we know it today will be ubiquitous and 'disappear into the background' as universal connectivity becomes the norm. So-called 'apps' will be integrated seamlessly within our homes, transportation and wearable devices. Advancements in security and privacy technologies should make this possible."

Ashok Goel, director of the Human-Centered Computing Ph.D. program at Georgia Tech, wrote, "The internet will become omnipresent, omniscient and almost omnipotent. Everyone in the world will have access to the internet and the internet will have access to everyone and almost everything. It will become the repository of all data about the whole world as well as human knowledge. Of course, there will be both cooperation and competition among individuals, institutions, corporations and countries on the use of this data and knowledge. A new set of values and law may be needed to enhance collaboration and manage confrontation. The internet 2069 will not only enable new kinds of commerce but also enable humans to collectively address seemingly intractable problems such as climate change and global warming."

Jean-Claude Heudin, a professor with expertise in AI and software engineering at Pole Universitaire Leonard de Vinci, France, wrote, "Internet will be everywhere, like the air: a cybersphere connecting all people, machines and objects. AI everywhere: embedded intelligence and ambient intelligence."

Theme 4: Visions of the future. From amazing advancements to dystopian developments, experts imagine a wide array of possible scenarios for the world 50 years in the future.

Responses representing this theme:

Baratunde Thurston, futurist, former director of digital at The Onion and co-founder of the comedy/technology startup Cultivated Wit, wrote, "It's the year 2069, and it's been 20 years since the conclusion of the Platform Wars and 30 years since Amazon bailed out and acquired the

United States of America. Shareholders were initially dumbfounded by Chairman Jeff Bezos's strategy, but it soon became clear that physical territory gave Amazon a significant competitive advantage over its onetime rivals, Alphabet, The People's Republic of Baidu and 4Chan.... Once it was proven in 2045 that a hybrid human-networked intelligence could manage and draft legislation far better than inconsistent and infinitely corruptible humans, the U.S. Congress was replaced with a dynamic network model accounting for the concerns of citizens yet bound by resource constraints and established laws."

Jerry Michalski, founder of the Relationship Economy eXpedition, said, "Half a century is a long time. Many futures seem possible; I'll describe one. Software has 'personhood.' It has rights, personality and limited responsibility. Cryptocurrencies and distributed systems have helped onethird of Earth's population separate from nation states and join 'nations of choice,' ranging from Burning Man to racially segregated enclaves. The digital platforms these nations use are larger and more powerful than the old nation-states. Few people have privacy or full-time jobs. Facts hardly exist: Everything is easy to fake, so everything is in doubt. Digital platforms still haven't figured out how to stop stalking us and use their presence and power to help us govern together better."

Jamais Cascio, research fellow at the Institute for the Future, wrote, "I imagine three broad scenarios for AI in 50 years. No. 1, EVERYWARE, is a crisis-management world trying to head off climate catastrophe. Autonomous systems under the direction of governance institutions (which may not be actual governments) will be adapting our physical spaces and behaviors to be able to deal with persistent heat waves, droughts, wildland fires, Category 6 hurricanes, etc.... No. 2, ABANDONWARE, is also crisis-driven, but here various environmental, economic and political crises greatly limit the role of AI in our lives. There will be mistrust of AI-based systems, and strong pushback against any kinds of human displacement. This likely results from political and economic disasters in the 2040s-ish linked to giving too much control to AI-based systems.... The dominant design language for AI here is *submissive*. AI is still around, but generally whimpering in the corner. No. 3, SUPERWARE, is the world described in the first answer (AI common but largely invisible) turned up to 11. In this scenario, AI systems focus on helping people live well and with minimal harm to others. By 2069, the only jobs performed by humans in the post-industrial, post-information world require significant emotional labor, unique creative gifts or are simply done out of the pleasure of doing them.... Most people born before 2020 *hate* this, seeing it as 'robo-nanny state socialism' and 'undermining human dignity' even as they take advantage of the benefits. The dominant design language for AI here is 'caring.' Machines of Loving Grace, whether you like it or not."

Hopeful visions of 2069

Theme 1: Living longer and feeling better. Internet-enabled technology will help people live longer and healthier lives. Scientific advances will continue to blur the line between human and machine.

Responses representing this theme:

Geoff Arnold, chief technology officer for the Verizon Smart Communities organization, predicted there will be "Better health. Less freedom. Less loneliness. Less work."

Andrew Tutt, an expert in law and author of "An FDA for Algorithms," said, "The era of complex automation will revolutionize the world and lead to groundbreaking changes in transportation, industry, communication, education, energy, health care, communication, entertainment, government, warfare and even basic research…. Intelligent AI will contribute immensely to basic research and likely begin to create scientific discoveries of its own…. Information will become more freely available. Everything will become cheaper. Miserable work – cleaning up after others, serving others, engaging in rote repeated thankless tasks – will continue its slow march to extinction. Our massively improved capacity to deal with suffering, both emotional and physical, is probably among the least-appreciated advances we will make. Empathetic machines will go a long way toward making people feel less lonely and more important. They may also help to teach us to be more moral."

Susan Etlinger, an industry analyst for Altimeter Group expert in data, analytics and digital strategy, commented, "We're also seeing a huge amount of research in the areas of prosthetics, neuroscience and other technologies intended to translate brain activity into physical form. All discussion of transhumanism aside, there are very real current and future applications for technology 'implants' and prosthetics that will be able to aid mobility, memory, even intelligence, and other physical and neurological functions."

Clark Quinn, executive director at Quinnovation, wrote, "In 50 years, we will have mastered the art of human augmentation. Our digital world will interact with our physical world seamlessly, so that our physical actions can have semantics, and vice-versa. Our senses will be amplified, the world will be annotated and there will be guidance and warnings on our actions."

Theme 2: Less work, more leisure. Artificial Intelligence (AI)-driven tools will take over repetitive, unsafe and physically taxing labor, leaving humans with more time for leisure.

Responses representing this theme:

Benjamin Kuipers, a professor of computer science at the University of Michigan, wrote, "The technological, often digital, tools we are creating have the promise of greatly increasing the

resources available in society. While it may be possible to automate some current jobs, people have an intrinsic need for meaningful work. If we can use these new resources to support them, many jobs can be created to provide meaningful work for many people and to improve the environment for everyone in society."

Ken Goldberg, distinguished chair in engineering, director of AUTOLAB and CITRIS at the University of California, Berkeley, said, "I believe the question we're facing is not 'When will machines surpass human intelligence?' but instead 'How can humans work together with machines in new ways?' … Rather than discouraging the human workers of the world with threats of an impending Singularity, let's focus on Multiplicity, where advances in AI and robots can inspire us to think deeply about the kind of work we really want to do, how we can change the way we learn and how we might embrace diversity to create myriad new partnerships."

Theme 3: Individualized experiences. Digital life will be tailored to users.

Responses representing this theme:

Michael Wollowski, associate professor of computer science and software engineering at RoseHulman Institute of Technology, wrote, "Much of our lives will be automated. Better yet, we will be in control of the degree of automation. Technology will assume the role of a polite personal assistant who will seamlessly bow in and out. Technology based on learned patterns of behavior will arrange many things in our lives and suggest additional options."

Greg Shannon, chief scientist for the CERT Division at Carnegie Mellon University's Software Engineering Institute, said, "Pervasive/complete/competing memories – capture/network/storage tech will allow complete digital records of each life, with fast recall for discussion, disagreements and manipulation. What will it mean to not have to remember, that you can recall the video with higher fidelity than one could ever remember?"

Pamela Rutledge, director of the Media Psychology Center, responded, "Technology gives individuals more control – a fundamental human need and a prerequisite to participatory citizenship and collective agency."

Theme 4: Collaboration and community. A fully networked world will enhance opportunities for global collaboration, cooperation and community development, unhindered by distance, language or time.

Responses representing this theme:

Mike Meyer, futurist and administrator at Honolulu Community College, commented, "The very nature of the technology that will become part of our bodies and will shape the very nature of our communities … [T]he natural result will be homogenization of the species. The nature of [the] planet will become predominantly urban with constant instantaneous communication. We are already well on the way to a planetary culture…. This may, finally, eliminate the problem of irrational bigotry, racism and xenophobia."

Gabor Melli, senior director of engineering for AI and machine learning for Sony PlayStation, responded, "By 2070, most people will willingly spend most of their lives in an augmented virtual reality. The internet and digital life will be extraordinary and partially extraplanetary. Innovations that will dramatically amplify this trajectory are unsupervised machine learning, fusion power and the wild card of quantum computing."

Craig Mathias, principal at Farpoint Group, an advisory firm specializing in wireless networking and mobile computing, commented, "Civilization itself centers on and thus depends upon communication of all forms. The more we communicate, the better the opportunities for peace and prosperity on a global basis. It would be difficult to imagine communications without the internet, now and especially in the future."

Theme 5: Power by the people. Expanded internet access could lead to further disruption of existing social and political power structures, potentially reducing inequality and empowering individuals.

Responses representing this theme:

Liz Rykert, president at Meta Strategies, a consultancy that works with technology and complex organizational change, responded, "We will see more and more integration of tools that support accountability…. The internet will let us both monitor and share data and images about what is happening, whether it is a devastating impact of climate change or an eventful incident of racism. Continued access to tools of accountability and access to knowledge and collaborative opportunities will support people."

Henry E. Brady, dean, Goldman School of Public Policy, University of California, Berkeley, wrote, "The biggest impact of the internet has been the creation of self-governing communities of interest that use 'hashtags' or 'likes' or other mechanisms to 'govern' themselves. It seems likely that these communities will grow and expand, creating powerful groups in cyberspace that may approach or exceed nations in their power in the world through their ability to express their needs and preferences and to find ways to reward those who help them…. Their power will also stem from their ability to exercise political and social authority through the dissemination of information and through political acts."

Worrisome visions of 2069

Theme 1: Widening divides. The divide between haves and have-nots will grow as a privileged few hoard the economic, health and educational benefits of digital expansion.

Responses representing this theme:

Grace Mutung'u, co-leader of the Kenya ICT Action Network, responded, "There will be loss of autonomy as humans integrate more with technology. This will have both positive and negative effects…. Technology will increase existing inequalities. At the moment, for example, low- and middle-income countries import technology and participate minimally in its design and creation. Most of the world's population is in low- and middle-income countries and already disadvantaged by it. They are likely to suffer technology colonialism."

Michael Kleeman, a senior fellow at the University of California, San Diego, and board member at the Institute for the Future, wrote, "Because of the economic disparity the new technologies will be used with those with access to more resources, financial and technical. *The digital divide will not be one of access but of security, privacy and autonomy*."

Fernando Barrio, director of the law program at the Universidad Nacional de Rio Negro, Argentina, commented, "The question is, with an ever-increasing income concentration at global scale in almost every country, how many members of the society will be able to be part of the enjoyment of that ubiquitous, hyper-connected, AI-tech society?"

Theme 2: Internet-enabled oppression. A powerful elite will control the internet and use it to monitor and manipulate, while providing entertainment that keeps the masses distracted and complacent.

Responses representing this theme:

Ken Birman, a professor in the department of computer science at Cornell University, responded, "Historians will be harsh when they judge us relative to this one aspect: The harm to entire cultures that oppressive monitoring and surveillance can cause is frightening, and those future historians will be in a position to document that harm – harm that people are actively inflicting today for all sorts of reasons."

Craig Burdett, a respondent who provided no identifying details, wrote, "The greatest challenge facing society is determining how much privacy and autonomy we are willing to cede in exchange for convenience and features…. The internet, in and of itself, is benign – like a handgun. But the companies and individuals behind the services are the greatest threat."

John Sniadowski, a director for a technology company, wrote, "To the vast majority of internet users, the internet is akin to making a cup of tea. You simply want to fill the kettle from the tap, switch on the kettle, boil the water and pour it onto the tea. They don't ever think about the infrastructure that makes that possible. This means that people will adopt any internet that makes life easier without thinking of the consequences."

Theme 3: Connected and alone. The hyperconnected future will be populated by isolated users unable to form and maintain unmediated human relationships.

Responses representing this theme:

Luke Stark, a fellow in the department of sociology at Dartmouth College and at the Berkman Klein Center for Internet & Society at Harvard University, wrote, "Increasingly ubiquitous digital systems will do a good job of cocooning individuals within personalized augmented reality bubbles, but a terrible job at facilitating durable connections between us. At the same time, those connections will be surveilled, measured, tracked and represented back to us in ways that will aim to make us more economically productive and socially pliant in the guise of 'wellness' and 'community.' These systems will increase social inequality through their dividuating effects and contribute to environmental degradation through their use of natural resources – a Philip K. Dick dystopia come to banal life."

A professor emeritus expert on technology's impacts on individuals' well-being wrote, "Sadly we will find ourselves spending nearly all of our time immersed in internet-based activities. We are already spending, on the average, more than five hours a day using our smartphones, and in 50 years smartphones will be replaced by smart devices, implants, etc. Relationships will suffer, as will our feelings of freedom."

Theme 4: The end of privacy. Personal privacy will be an archaic, outdated concept as humans willingly trade discretion for improved health care, entertainment opportunities and promises of security.

Responses representing this theme:

Betsy Williams, a researcher at the Center for Digital Society and Data Studies at the University of Arizona, wrote, "Privacy will be largely a luxury of the rich, who will pay extra for internet service providers, services and perhaps separate networks that protect privacy and security."

Vian Bakir, a professor of political communication and journalism at Bangor University, responded, "Assuming that the commercial impetus remains dominant, that international regulation remains weak, and that people remain willing to give away their data for access to the

internet and apps, then I foresee a dysfunctional future where dataveillance reigns supreme, and where privacy (and associated freedoms) has become a distant memory."

Theme 5: Misallocated trust. Digital life lays you bare. It can inspire a loss of trust, often earns too much trust and regularly requires that you take the plunge even though you have absolutely no trust.

Responses representing this theme:

Thad Hall, a research scientist and coauthor of "Politics for a Connected American Public," wrote, "The ability of the news media to report facts will be hampered by a cascade of alternate news, with different video and audio of the exact same event. Things as simple as what the president said in a meeting will be constantly up for debate as instant, real-time alternate feeds show something different, presenting a different worldview. There will be greater segmentation of the population and divisions that separate people. People are likely to become more polarized and tribal over the next 50 years. People will be pushed in different directions by advertisers, who will segment us in ways so that people will not even be aware of certain products others use. We will receive different news, again exacerbated by the prevalence of fake news that is exceedingly difficult to discern from reality."

Alan Mutter, a longtime Silicon Valley CEO, cable TV executive and now a teacher of media economics and entrepreneurism at the University of California, Berkeley, said, "I hope internet users in the future will have more control over their data, interactions and the content pushed to them, but I fear that the platform companies – Google, Facebook, Amazon, Baidu and others – will take us in the opposite direction. A safe and satisfying user experience requires far more thought, work and time than the average user can muster. So, we will be at the mercy of the platforms."

Theme 6: "There is no planet B." The future of humanity is inextricably connected to the future of the natural world. Without drastic measures to reduce environmental degradation, the very existence of human life in 50 years could be in question.

Responses representing this theme:

Divina Frau-Meigs, UNESCO chair for sustainable digital development, said, "Environmental issues will be the primary problem everybody will want to solve in the next 50 years. There is no planet B."

Eliot Lear, principal engineer at Cisco, said, "With another 50 years under our belts, hopefully we will have by then models for resiliency, privacy and security that are tied to societal norms such

that people can rely on technology to have saved the planet. We will use the internet to predict environmental costs of human activity such that they can be minimized and perhaps even offset."

Judith Donath, author of "The Social Machine, Designs for Living Online" and faculty fellow at Harvard University's Berkman-Klein Center for Internet and Society, commented, "Western civilization, pinnacle of individual liberty, has culminated in the reckless and wasteful consumption of the Earth's natural resources: We've polluted the water, paved over the land, cut down the forests, strip-mined the mountains. Confronted with the apocalyptic specter of humaninduced mass extinctions and disastrous climate change, we as a species appear to have chosen to do nothing.... [N]ow imagine an artificially intelligent government, programmed to rebalance humans and the natural world as painlessly as possible. Though there would be no privacy from the machine government's ceaseless sensing, it would be a pleasant world. We would enjoy an apparent wealth of choice – the illusion of liberty. In reality, personal agency would be quite minimal, our desires redirected and our behavior shaped by subtle, powerful nudges. It may be the only hope we have left."

2. Internet pioneers imagine the next 50 years

People who have had the internet at their fingertips since birth can find it difficult to imagine a world in which information and communication are not readily available with a quick click or swipe or voice command to a phone. The following insights come from respected pioneers – many of them inductees to the Internet Hall of Fame – who were present during the birth and infancy of the internet.

'Pervasive global nervous system' comes from the 'Internet of Invisible Things'

Leonard Kleinrock, Internet Hall of Fame member and co-director of the first host-to-host online connection and professor of computer science, University of California, Los Angeles, said, "I predict that the internet will evolve into a pervasive global nervous system. The internet will be everywhere, available on a continuous basis, and will be invisible in the sense that it will disappear into the infrastructure, just as electricity is, in many ways, invisible. The Internet of Things will be an embedded world of the Internet of Invisible Things. We will be able to interact with its capabilities via human-friendly interfaces such as speech, gestures, haptics, holograms, displays and so on. No more will we be forced to interface with tiny, incompatible, awkward keyboards, icons and clumsy hand-held and desktop devices. These interfaces will be highly customized to each individual and matched to their profile, preferences, privileges and specifications in an

adaptable fashion. My hope is that life will calm down and provide a more balanced physical/digital presence. Screens will diminish considerably, bringing us back to enriched human-human interaction, notwithstanding that a significant fraction of our interaction will be enhanced with software agents, avatars and AI devices (robots, embedded devices, etc.). We will no longer be adjusting to the awkward software and hardware interfaces we currently endure, but the customization of these interfaces will be better matched to what we desire and expect as individuals. Such interactions will enable humans and AI devices to participate in a joint exchange far more easily than is the case today where it is either human or AI device, but not easily both."

'Beyond Mars and down to molecules'

Bob Metcalfe, Hall of Fame co-inventor of Ethernet, founder of 3Com and now a professor of innovation and entrepreneurship at the University of Texas, Austin, said, "In 50 years people will not have to type in IP numbers…. The internet is not merely a network of networks. It is a network of networks of networks. The ARPANET was a network. In 1973 at Stanford, Vint Cerf wanted to network ARPANETs around the world in a network of networks. Meanwhile, I wanted to use the ARPANET to network Ethernets inside buildings. Both of us were right, and we got a network of networks of networks. This simultaneous growing up and down will continue, beyond Mars and down to molecules, somehow."

An international 'law of the net' treaty might be needed to solve challenges

Vint Cerf, Internet Hall of Fame member and vice president and chief internet evangelist at Google, wrote, "The 1969 date is ARPANET connection, not internet which doesn't exist until designed in 1973 and turned on in 1983. Connectivity in the future will be ubiquitous. Much will be high-speed wireless. Optical fiber needed to link wireless termination points. IP address space might be replaced with something else in 50 years' time or IP addresses may be reinterpreted as logical rather than physical addresses – just as telephone numbers have morphed as mobile communication and number portability have emerged as requirements to support. Endpoints will nominally filter incoming traffic (or go through firewalls) to block unwanted connections. I still see the computing and communication environment as positive and constructive but it does create avenues for remotely initiated harmful behaviors, amplification through botnets, etc. International agreements and mechanisms for traceability of actors in the network will be needed to respond to harmful behavior. A law of the net will likely have to be enacted (international treaty) to cope with these challenges. I continue to see these technologies as constructive and augmenting."

'Roads will be used for driverless transport of goods or pleasure'

Lawrence Roberts, designer and manager of ARPANET, the precursor to the internet, and Internet Hall of Fame member, commented, "Within 50 years we will have the technology for

embedding internet transceivers into human brains. This could greatly speed up information transfer and allow great advances. However, the flood of advertising would need to be controlled and security would need to have improved greatly for anyone to take the risk. The internet has evolved little in the last 50 years except to grow bigger. With so much invested in the current design, it is hard to see the underlying transport changing fast. A great number of jobs will be able to be done totally over the internet. That could be from home or from the brain implant. Robots will do the majority of the physical jobs often with a remote person overseeing the activity, but largely managed with AI. Most commuting will cease, and roads will be used for driverless transport of goods or pleasure. AI will incorporate logic and rules to make it safe, not just deep learning neural networks."

Centralization of personal data will be irreversible in an 'information hegemony'

Paul Vixie, an Internet Hall of Fame member known for designing and implementing several Domain Name System protocol extensions and applications, wrote, "The most active force vectors in the humanity equation right now all relate to the acquisition and preservation of power. We will have passed peak-cloud in 50 years. Azure grows faster than Amazon Web Services, and billions of dollars are being invested in private data centers and private cloud. However, the centralization of retail transactions and personal information will be irreversible due to the extreme cost of creating a viable competitor in an information hegemony in which corporations, churches and foreign governments know more and have more influence than anything that can be understood by a democratically elected government."

'We will need a whole new social paradigm to deal with this'

Elizabeth Feinler, the original manager of the ARPANET Network Information Center and an Internet Hall of Fame member, said, "It will be interesting to see whether the internet and computers augment our intelligence and lives, or whether they replace them. Surely, many more things will be automated, which will mean that jobs will be lost and humans will be less involved in the daily performance of their lives. We will need a whole new social paradigm to deal with this. The internet is technically complex. It is also the underpinning for a great deal of American industry, business and finance, not to mention our democracy. More and more it controls our infrastructure. We cannot expect our elected lawmakers to understand all of this as they try to come up with reasonable laws affecting the internet. We need a multilateral body (or bodies) of internet/computer experts, elected among themselves, to serve as an independent authority to provide technical guidance and expertise to the government.

Watch the rise of multi-stakeholder organizations

Steve Crocker, CEO and co-founder of Shinkuro Inc., internet pioneer and Internet Hall of Fame member, responded, "It was evident at the very beginning of the ARPANET that network connections would become commonplace. Everyone would want their computer connected. With the creation of the internet and the opening to commercial connections in the 1990s, the pace of interconnection accelerated. Today, half or more of the world's population is continuously connected. I think the internet will start to be built into devices and systems, more or less below the surface. People will stop referring to the internet and take it for granted, much as the developed world takes electric power for granted. This will take a fair amount of engineering, standards development and improved operational practices, of course, but that's just a continuation of the path we've been on for 50 years. Laws and regulations will be under pressure to keep up. The existing boundaries between countries and between states in the U.S. will be hurdles. Cooperation across these jurisdictions will evolve, partly through multilateral agreements and partly through the increased use of multi-stakeholder organizations."

Brain-computer interfaces will emerge, as will nightmares about privacy

Wendy Hall, professor of computer science at the University of Southampton, UK, and executive director of the Web Science Institute, said, "I really don't think we will have an internet as we know it today in 2069. Think back to 1969 – most of the technologies we take for granted today (including a global information system such as the web) were just science fiction then. I believe the biggest factors that are leading to the fragmentation of the internet today are the geopolitical factors and the potential weaponization of the internet. So, its future is by no means certain. But the development of technology continues apace. I believe that by 2069 the brain-machine interface will be fully developed, and if we think the applications of AI might be terrifying for the future of humanity, then brain-computer interfaces are the stuff of nightmares if the legal and ethical frameworks under which they are used are not carefully considered from the outset. I am sure there will be other technologies, maybe developed by AI, that we don't know about yet but will dominate the world in 2069 like the internet does in 2019."

Smart prosthetics and other smart things will be common

Craig Partridge, chief scientist at Raytheon BBN Technologies for 35 years and Internet Hall of Famer, currently chair of the department of computer science at Colorado State University, wrote, "Here's one example of things being better: I think we're only just beginning to understand smart physical things. I'm thinking of better prosthetic limbs, load-bearing walls with embedded sensors and actuators that keep the building standing during an earthquake, and hiking-shoe soles that better grip uneven ground."

The next phase of the internet will be 'politically driven'

Teus Hagen, Netherlands internet pioneer, former chair and director of NLnet and member of the Internet Hall of Fame, commented, "The next 50 years? Over the past 50 years it was impossible to know what was next, and it is still impossible. The forces that drive technology in years further in the future may no longer be based in the 'Western countries,' and the concept of the internet being 'free' will go away. The leading companies like Google, Microsoft and Apple will become minor in importance. Individuals will not be able control their individual lives nor be able to tell who they are and what they want to be. The problem is not that there is one entity that controls information, but so many different people from so many cultures and jurisdictions. The internet has had a technology-driven evolution, but it will become politically driven if we keep on building the Towers of Babel."

New developments will be extrapolations of the past

Arthur Bushkin, an IT pioneer who worked with the precursors to ARPANET and Verizon, wrote, "Having been present at the creation, along with many others, I've been struck by the extent to which many new developments were extrapolations of past developments. Two major 'new' qualitative developments were wireless and miniaturization. Widespread application of 'artificial intelligence' has the potential be another such 'new' qualitative development in the years ahead. Technological development always has the potential to impact human development. In the end, I am an optimist."

In schools, 'education politics' have stifled new tech-based learning methods

Ed Lyell, longtime internet strategist and professor at Adams State University, responded, "I was one of the first to use ARAPNET as a graduate student at San Francisco State working with a Stanford professor. We received grants to test using terminal-based connections to tutor inner-city black youth in algebra and discovered that even the primitive terminal of 'blue-screen' DOS was a better tutor than the white female teacher or a black college student coming into the student's home in the evening because the computer did not care how many mistakes were made but forced you to continue to work until you obtained that competency. I wrote a master's thesis on the use of computer-assisted instruction in 1970 and predicted that they would transform learning in just a few years. Yet a lifetime later not much has changed. I remain optimistic, guided by some charter schools, DSST (credit-by-examination testing), and magnet schools using technology to more dramatically improve student learning. The politics of education (K-12 and higher education) shut down innovation. Thus, I could say that we might create the kind of learning that I wrote about in 'Nickelodeon' magazine back in 1985, wherein going to school would be 24/7 with a wristwatch computer on your wrist and the internet at your fingertips."

There will be 'less privacy, less democracy, less individual self-esteem'

A member of the Internet Hall of Fame said, "In 1970, today's internet could not have been predicted. The election of a black president could not have been predicted 50 years before. All one can do is linearly extrapolate from the present. For example, Edward Bellamy's classic 'Looking Backward' did not come close to predicting the technologies of 50 years later. He just extrapolated from his present. There are occasional geniuses such as Jules Verne, but such are very, very sparse. One easy thing to predict is that 50 years from now the world will be coping with massively changed weather. [I believe things will be worse in future because I expect] less privacy, less democracy and less individual self-esteem."

'We had no idea where it would go'

An internet pioneer, company founder and president and 1970s manager of an AI center said, "I was one of the early internet builders. We had no idea where it would go. What became Google makes sense. Just build a huge catalog of data. Curating that is a delicate endeavor. Humans will disagree on that for eternity."

Lives will improve

An Internet Hall of Fame member expert in network architecture wrote, "I anticipate that, on balance, innovations that make use of the internet will improve the lives of many people more than the negative impact that will be associated with some aspects of our increasingly digital lives. Better health care, real-time language translation and a host of other capabilities that can improve lives."

3. Humanity is at a precipice; its future is at stake

The following sections share selections of comments from technology experts and futurists who elaborate on the ways internet use has shaped humanity over the past 50 years and consider the potential future of digital life. They are gathered under broad, overarching ideas, rather than being tied to the specific themes highlighted above. Many of the answers touch on multiple aspects of the digital future and are not neatly boxed as addressing only one part of the story. Some responses are lightly edited for style and readability.

The cautious optimism expressed by many of the experts canvassed for this report grew out of a shared faith in humanity. Many described the current state of techlash as a catalyst that will lead to a more inclusive and inviting internet. Some of these comments are included below.

Micah Altman, a senior fellow at the Brookings Institution and head scientist in the program on information science at MIT Libraries, wrote, "The late historian Melvin Kranzberg insightfully observed, 'Technology is neither good nor bad; nor is it neutral.' In the last 50 years, the internet has been transformative and disruptive. In the next 50, information, communication and AI technology show every sign of being even more so. Whether historians of the future judge this to be good or bad will depend on whether we can make the societal choice to embed democratic values and human rights into the design and implementation of these systems."

Juan Ortiz Freuler, a policy fellow, and **Nnenna Nwakanma**, the interim policy director for Africa at the Web Foundation, wrote, "Unless we see a radical shift soon, the internet as we know it will likely be recalled as a missed opportunity. History will underline that it could have been the basis for radically inclusive societies, where networked communities could actively define their collective future. A tool that could have empowered the people but became a tool for mass surveillance and population control. A tool that could have strengthened the social fiber by allowing people to know each other and share their stories, but out of it grew huge inequalities between the connected and not-connected, both locally and across countries."

Steven Miller, vice provost and professor of information systems at Singapore Management University, said, "Overall, the future will be mostly for the better. And if it is not mostly for the better, the reasons will NOT be due to the technology, per se. The reasons will be due to *choices* that people and society make – political choices, choices per how we govern society, choices per how we attend to the needs of our populations and societies. These are people and political issues, not technology ones. These are the factors that will dominate whether people are better off or worse off."

Paul Jones, professor of information science at the University of North Carolina, Chapel Hill, responded, "While the internet was built from the beginning to be open and extensible, it relies on communities of trust. As we are seeing this reliance has strong downsides – phishing, fake news, over-customization and tribalism for starters. Adding systems of trust, beginning with the promises of blockchain, will and must address this failing. Will the next internet strengthen the positives of individualism, of equality and of cooperation or will we become no more than Morlocks and Eloi? I remain optimistic as we address not only the engineering challenges, but also the human and social challenges arising. All tools, including media, are extensions of man. 'We shape our tools and thereafter our tools shape us,' as McLuhan is credited for noticing. Nothing could be more true of the next internet and our lives in relation to information access. Can we create in ways now unknown once we are less reliant on memorization and calculation? Will we be better at solving the problems we create for ourselves? I answer with an enormous 'Yes!' but then I'm still waiting for the personal jetpack I was promised as a child."

Ray Schroeder, associate vice chancellor for online learning at the University of Illinois, Springfield, wrote, "On the scale of the discovery of fire, the wheel and cultivation of crops, the interconnection of humans will be judged as a very important step toward becoming the beings of the universe that we are destined to be."

Charlie Firestone, communications and society program executive director and vice president at the Aspen Institute, commented, "Fifty years from now is science fiction. There really is no telling with quantum computing, AI, blockchain, virtual reality, broadband (10G?), genetic engineering, robotics and other interesting developments affecting our lives and environments…. It's just too far ahead to imagine whether we will be in a digital feudal system or highly democratic. But I do imagine that we could be on our way to re-speciation with genetics, robotics and AI combined to make us, in today's image, superhuman. I understand that there are many ways that the technologies will lead to worse lives, particularly with the ability of entities to weaponize virtually any of the technologies and displace jobs. However, the advances in medicine extending lives, the ability to reduce consumption of energy, and the use of robotics and AI to solve our problems are evident. And we have to believe that our successors will opt for ways to improve and extend the human species rather than annihilate it or re-speciate."

Edward Tomchin, a retiree, said, "Human beings, homo sapiens, are a most remarkable species which is easily seen in a comparison with how far we have come in the short time since we climbed down out of the trees and emerged from our caves. The speed with which we are currently advancing leaves the future open to a wide range of speculation, but we have overcome much in the past and will continue to do so in pursuit of our future. I'm proud of my species and confident in our future."

Garland McCoy, founder and chief development officer of the Technology Education Institute, wrote, “I hope in 50 years the internet will still be the Chinese fireworks and not become the British gunpowder.”

Angelique Hedberg, senior corporate strategy analyst at RTI International, said, “If we choose a future we want in 50 years, and work toward creating it, there is a nonzero probability we will reach a version of that future. In that vein of thought, we will see waves of platform companies that change the way we live and enjoy our lives. The platform companies that exist today will fade, as will the ones that follow. This is not because they fail, but rather, because they succeed. We will find a way to make decisions in a network of decisions. In 50 years, multiple generations of a family will gather for dinner and share sights, smells, sounds, tastes and touches, even if they are in different hemispheres, countries and time zones. You’ll be at a child’s social activity and they will hear the voices [of] all of those who love (and critique) him. You will say goodbye to aging loved ones, even if they cannot hear you. This will all happen with the assistance of technology (some embedded in our brain) that know our wants and needs better than we know our own. The definition of what it means to be human will evolve and the laws and regulation will follow, albeit in a less than direct manner. We will value governments in new and different ways, and we will expect more from our technology platforms. The deluge of data will provide new inputs into the decision models for platforms, bringing greater clarity to the short-term benefits and long-term risks, in return making the financial decisions more social, environmental and moral. Where laws and regulations can put a bottom line, they will. Where law and regulations cannot, the planet will step in and regulate the excess.”

Daniel Riera, a professor of computer science at Universitat Oberta de Catalunya, commented, “Everything will be connected; automation will be everywhere; most of the jobs will be done by machines. Society will have fully changed to adapt to the new reality: Humans will need to realize the importance of sustainability and equality. In order to reach this point, technology, ethics, philosophy, laws and economics, among other fields, will have done a big joint effort. We have a very good opportunity. It will depend on us to take advantage of it. I hope and trust we will. Otherwise, we will disappear.”

Geoff Livingston, author and futurist, commented, “This is a great period of transition. The internet forced us to confront the worst aspects of our humanity. Whether we succumb or not to those character defects as a society remains to be seen.”

Brad Templeton, chair for computing at Singularity University, software architect and former president of the Electronic Frontier Foundation, responded, “It’s been the long-term arc of history to be better. There is the potential for nightmares, of course, as well as huge backlashes against the

change, including violent ones. But for the past 10,000 years, improvement has been the way to bet."

Mary Chayko, author of "Superconnected: The Internet, Digital Media, and Techno-Social Life" and professor in the Rutgers School of Communication and Information, said, "The internet's first 50 years have been tech-driven, as a host of technological innovations have become integrated into nearly every aspect of everyday life. The next 50 years will be knowledge-driven, as our understandings 'catch up' with the technology. Both technology and knowledge will continue to advance, of course, but it is a deeper engagement with the internet's most critical qualities and impacts – understandings that can only come with time, experience and reflection – that will truly come to characterize the next 50 years. We will become a 'smarter' populace in all kinds of ways."

Yvette Wohn, director of the Social Interaction Lab and expert on human-computer interaction at New Jersey Institute of Technology, commented, "Technology always has and always will bring positive and negative consequences, but the positives will be so integral to our lives that going back will not be an option. Cars bring pollution, noise and congestion but that doesn't mean we're going back to the horse and buggy. We find newer solutions, innovation."

Bob Frankston, software innovation pioneer and technologist based in North America, wrote, "For many people any change will be for the worse because it is unfamiliar. On the positive side, the new capabilities offer the opportunity to empower people and provide solutions for societal problems as long as we don't succumb to magical thinking."

Matt Mason, a roboticist and the former director of the Robotics Institute at Carnegie Mellon University, wrote, "The new technology will present opportunities for dramatic changes in the way we live. While it is possible that human society will collectively behave irrationally and choose a path detrimental to its welfare, I see no reason to think that is the more likely outcome."

Stuart A. Umpleby, a professor and director of the research program in social and organizational learning at George Washington University, wrote, "In the future people will live increasingly in the world of ideas, concepts, impressions and interpretations. The world of matter and energy will be mediated by information and context. Already our experiences with food are mediated by thoughts about calories, safety, origins, the lives of workers, etc. Imagine all of life having these additional dimensions. Methods will be needed to cope with the additional complexity."

John Markoff, fellow at the Center for Advanced Study in Behavioral Sciences at Stanford University and author of "Machines of Loving Grace: The Quest for Common Ground Between Humans and Robots," wrote, "Speculation on the nature of society over timespans of half a century

falls completely into the realm of science fiction. And my bet is that science fiction writers will do the best job of speculating about society a half century from now. As someone who has written about Silicon Valley for more than four decades I have two rules of thumb: technologies aren't real until they show up at Fry's Electronics and the visionaries are (almost) always wrong. I actually feel like the answer might as well be a coin toss. I chose to be optimistic simply because over the past century technology has improved the quality of human life."

An executive director for a major global foundation wrote, "The internet will rank among the major technology movements in world history – like gunpowder, indoor plumbing and electricity. And like all of them (with the possible exception of indoor plumbing), its eventual weaponization should have been less of a surprise."

Bryan Johnson, founder and CEO of Kernel, a leading developer of advanced neural interfaces, and OS Fund, a venture capital firm, said, "Humans play prediction games, but the exercise is inherently unproductive. A more useful exercise would be to think about what deeply influential technology can we invest our current time in that will give us the tools we need to thrive in such a highly complex future. Forecasting to 2050 is thought junk food. It is what people most like to daydream about, but is not what we should think about for the health of the species and planet."

Ethics and the bigger picture loom large in the digital future

Optimistic and pessimistic respondents alike agree that human agency will affect the trajectory of digital life. Many respondents said their biggest concern is that everyone's future in the digital age depends upon the ability of humans to privilege long-term societal advancement over short-term individual gain.

William Uricchio, media scholar and professor of comparative media studies at MIT, commented, "'Changes in digital life' are human-driven; technology will only amplify the social structures that created it. My pessimism ensues from the polarization of power, knowledge and wealth that characterizes much of the world at the start of the 21st century, and by the rapidly growing pressures evident in population growth and ecological degradation. Digital technologies have the capacity to be terrific enablers – but the question remains, enablers of what? Of whose vision? Of what values? These, it seems to me, are the defining questions."

Jonathan Swerdloff, consultant and data systems specialist for Driven Inc., wrote, "In the first 50 years of connected internet, humanity rose from no access at all to always-on, connected devices on their person tracking their life signs. I expect the next 50 years will see devices shrink to tiny sizes and be integrated within our very persons. Then there will be two inflection points. The first will be a split between the technology haves and have-nots. Those who have the technology will benefit from it in ways that those who do not are unable to. The more advanced technology

gets the more this will be the case. While I would like to believe in a utopic vision of AI fighting climate change and distributing food and wealth so that nobody goes hungry – the 'Jetsons' future, if you will – history doesn't support that view. The second will be a moral evolution. Privacy as conceived in the era before the advent of the internet is nearly dead despite attempts by the European Union and California to hold back the tide. The amount of information people give up about their most private lives is growing rapidly. A commensurate evolution of morals to keep up with the technological developments will be required to keep up or chaos will ensue. Moral structures developed when people could hide their genetics, personal habits and lives at home are not aligned with an always-on panopticon that knows what someone is doing all day every day. Human nature is nearly immutable – morals will need to catch up…. Anything that happens in society can be magnified by technology. I hope that my pessimism is wrong. There is some evidence of the moral evolution already – Millennials and the generation behind them freely share online in ways which Boomers and Gen X look at as bizarre. Whether that will lead to a significant moral backlash in 50 years remains to be seen."

Susan Mernit, executive director, The Crucible, and co-founder and board member of Hack the Hood, responded, "I am interested in how wearable, embedded and always-on personal devices and apps will evolve. Tech will become a greater helping and health-management tool, as well as take new forms in terms of training and educating humans. But I wonder how much humans' passivity will increase in an increasingly monitored and always-on universe, and I wonder how much the owners and overlords of this tech will use it to segment and restrict people's knowledge, mobility and choices. I want to believe tech's expansion and evolution will continue to add value to people's lives, but I am afraid of how it can be used to segment and restrict groups of people, and how predictive modeling can become a negative force."

Charles Ess, a professor expert in ethics with the Department of Media and Communication, University of Oslo, Norway, said, "My overall sense of the emerging Internet of Things and its subsequent evolutions is of an increasing array of technologies that are ever more enveloping but also ever more invisible (advanced technology is magic, to recall Arthur C. Clarke), thereby making it increasingly difficult for us to critically attend to such new developments and perhaps rechannel or obviate them when ethically/socially indicated."

Stavros Tripakis, an associate professor of computer science at Aalto University (Finland) and adjunct at the University of California, Berkeley, wrote, "Misinformation and lack of education will continue and increase. Policing will also increase. Humanity needs a quantum leap in education (in the broad sense) to escape from the current political and economic state. Fifty years is not enough for this to happen."

Kenneth R. Fleischmann, an associate professor at the University of Texas, Austin School of Information, responded, "The key questions are, 'Which individuals?' and 'Better/worse in which ways?' The impacts on different people will be different, and each person will interpret these changes differently. One major factor is what people value or consider important in life. If people value privacy and they are subject to a digital panopticon then, in that way, their lives may be worse; however, they also likely value convenience, and may find substantial improvements in that regard. Different people will make that tradeoff differently depending on what they value. So, understanding the impact of the technology is not only about predicting the future of technology, it is also about predicting the future of what we value, and these two considerations are of course mutually constitutive, as technologies are shaped by values, and at the same time, over time (especially generations), technologies shape values."

Justin Reich, executive director of MIT Teaching Systems Lab and research scientist in the MIT Office of Digital Learning, responded, "Shakespeare wrote three kinds of plays: the tragedies where things got worse, the comedies where things got better, and the histories, with a combination of winners and losers. Technological advances do little to change net human happiness, because so much of happiness is determined by relative comparisons with neighbors. The primary determinants of whether life for people improves will be whether we can build robust social institutions that distribute power widely and equally among people, and whether those institutions support meaningful relationships among people."

Michiel Leenaars, director of strategy at NLnet Foundation and director of the Internet Society's Netherlands chapter, responded, "What the internet will look like in 50 years will greatly depend on how we act today. Tim Berners-Lee in his 2018 Turing speech referred to the current situation as 'dystopian,' and this seems like an adequate overall description. The industry is dominated by extremely pervasive but very profitable business practices that are deeply unethical, driven by perverse short-term incentives to continue along that path. A dark mirror version of the internet on an extractive crash course with democracy and the well-being of humanity at large itself. That is a future I'm not very eager to extrapolate even for another 10 years. My target version of the internet in 50 years – the one I believe is worth pursuing – revolves around open source, open hardware, open content as well as in helping people live meaningful lives supported by continuous education and challenging ideas. Permissionless innovation is a necessary precondition for serving the human potential, but so are critical reflection and a healthy social dialogue avoiding personalized bubbles, AI bias and information overload. The openness of the web and the mobile ecosystem in particular are abysmal, and attention and concentration are endangered human traits. But that can be reversed, I believe. Every day we can start to re-imagine and re-engineer the internet. The information age can and should be an era that brings out the best in all of us, but this will not happen by itself. So, I hope and believe the internet in 50 years is

going to be as challenging as the early internet – and hard work for many people that want to see this future emerge."

Simon Biggs, a professor of interdisciplinary arts at the University of Edinburgh, said, "Given our history as a species, and our current behavio with the internet, I suspect that our activities (within a more advanced form of the internet) will consist of virtual simulated sex (in the form of interactive pornography – so not really sex but power-play) and killing virtual players in massive online gaming environments (more power-play). In that sense things will be similar to how they are now. Given current trends it is likely that the internet will no longer be 'the internet,' in the sense that it was intended as the network of all networks. Networked information and communications technology will be territorialized, broken up and owned, in walled environments (this process is already well advanced). Access will be privileged, not for the consumer but for the producer. The first period of the internet was marked by a democratization of access to the means of production, but this will not be the case in the future. The vast bulk of internet users will be passive consumers who are offered an illusion of agency in the system to deliver them as a resource to those who profit from consumer playbour. We already see this with Facebook and other companies. The manner in which user data from Facebook and elsewhere has been exploited in the democratic process to affect the outcomes to the benefit of those paying for the data is indicative of where the internet is going. I expect the internet to be far more pervasive than it is today, our experience of our lived life mediated at all times. The only question is to what degree our experiential life will be mediated. I suspect it will be more or less total by 2030. Primarily, my reasoning is predicated on the expectation that human behaviour will lead to negative consequences flowing from our technological augmentation. These consequences could be quite severe. Do I think our survival as a species is threatened by our technological evolution? Yes. Do I think we will survive? Probably, because we are a tenacious animal. Do I think it will be worth surviving in a world like that? Probably not. Do I think the world would be better off if, as a species, we were to not survive? Absolutely. That is one thing we might hope for – that we take ourselves out, become extinct. Even if we are replaced by our machines the world is likely to be a better place without us."

Robert Bell, co-founder of Intelligent Community Forum, had a different view from Biggs, predicting, "We created something that became a monster and then learned to tame the monster."

Jeff Johnson, computer science professor at the University of San Francisco, previously with Xerox, HP Labs and Sun Microsystems, responded that it is important to take a broader view when assessing what may be coming next. He wrote, "Technological change *alone* will not produce significant change in people's lives. What happens alongside technological change will affect how technological change impacts society. The future will bring much-improved speech-controlled user interfaces, direct brain-computer interfaces, bio-computing, advances in AI and much higher

bandwidth due to increases in computer power (resulting from quantum computing). Unless national political systems around the world change in ways to promote more equitable wealth distribution, the future will also bring increased stratification of society, fueled by loss of jobs and decreased access to quality education for lower socio-economic classes. Finally, rising sea levels and desertification will render large areas uninhabitable, causing huge social migrations and (for some) increased poverty."

An associate professor of computer science at a U.S. university commented, "Humans have adapted poorly to life in a technological society. Think of obesity, time wasted on low-quality entertainments, addictions to a whole range of drugs and more. As the noise in the information stream increases, so does the difficulty for the average person to extract a cohesive life pattern and avoid the land mines of dangerous or unhealthy behaviors. Genetics, cultural change, social and legal structures do not change exponentially, but aggregate knowledge does. This mismatch is a crucial realization. As Reginald Bretnor noted in 'Decisive Warfare,' kill ratios for weapons not only increase, but so does their ability to be wielded by the individual. So it is with most things in a technologically advanced society. But have people cultivated the requisite wisdom to use what is available to better themselves? Looking at American society, I would generally conclude not."

The chief marketing officer for a technology-based company said, "I am all-in for innovation and improving the standard of living for all humanity. However … we need to become more vigilant about our fascination with technology and self-indulgence. Yes, it does paint a darker picture and forces a more cautious approach, but some of us are required to do this for the sake of a more balanced and fair future for all humanity. I'm one of the lucky ones, born in Europe with a very high standard of living. Same goes for the people behind this research. Let's be vigilant of our actions and how we shape the future. We have been in a constant battle with nature and resources for the past 100 years. In historical terms it was a momentous leap forward in education, connectivity, traveling, efficiency, etc. But, at the same time, we are all committing an environmental suicide and behave like there is no tomorrow – only the instant pleasure of technology. There will not be a tomorrow if we continue to ignore the cause and effect of our unipolar obsession with technology and self-indulgence."

Miguel Moreno-Muñoz, a professor of philosophy specializing in ethics, epistemology and technology at the University of Granada, Spain, said, "Mobility and easy access to affordable databases and service platforms for most citizens will become more important; e-government systems, transparency and accountability will be improved. The development of certain applications, if paralleled by the development of new types of intellectual property licensing and management systems, can revolutionize education and access to knowledge and culture. But this requires an open framework for international cooperation, which in many ways is now under threat."

Sam Gregory, director of WITNESS and digital human rights activist, responded, "My perspective comes from considering the internet and civic activism. We are at a turning point in terms of whether the internet enables a greater diversity of civic voices, organizing and perspectives, or whether it is largely a controlled and monitored surveillance machine. We are also swiftly moving toward a world of pervasive and persistent witnessing where everything is instantly watched and seen with ubiquitous cameras embedded in our environment and within our personal technologies, and where we are able to engage with these realities via telepresence, co-presence and vicarious virtual experience. This is a double-edged sword. The rise of telepresence robots will enable us to experience realities we could never otherwise physically experience. This remote experiencing has the potential to enable the best and the worst in our natures. On the one hand, we will increasingly have the ability to deliberately turn away from experiencing the unmitigated pain of the world's suffering. We might do this for the best of reasons – to protect our capacity to keep feeling empathy closer to home and to exercise what is termed 'empathy avoidance,' a psychological defense mechanism which involves walling ourselves up from responding emotionally to the suffering of others. We may also enter the middle ground that Aldous Huxley captured in 'Brave New World,' where narcotizing multisensory experiences, 'feelies,' distract and amuse rather than engage people with the world. Here, by enabling people to experience multiple dimensions of others' crises viscerally but not meaningfully, we perpetuate existing tendencies in activism to view other people's suffering as a *theatrum mundi* played out for our vicarious tears shed in the safety of our physically walled-off and secure spaces. On the other hand, we will increasingly be presented with opportunities through these technologies to directly engage with and act upon issues that we care about. As we look at the future of organizing and the need to better support on-the-ground activism, this becomes critical to consider how to optimize. We also have a potential future where governments will thoroughly co-opt these shared virtual/physical spaces, turning virtual activism into a government-co-opted 'Pokémon Go,' a human-identity search engine, scouring virtual and physical spaces in search of dissidents. In a brighter future, virtual/physical co-presence has the exciting potential to be a massive amplifier of civic solidarity across geographical boundaries, defying the power of national governments to unjustly dictate to their citizens."

Marc Rotenberg, director of a major digital civil rights organization, commented, "There is no question that the internet has transformed society. We live in a world today far more interconnected than in the past. And we have access almost instantaneously to a vast range of information and services. But the transformation has not been without cost. Concentrations of wealth have increased. Labor markets have been torn apart. Journalism is on the decline, and democratic institutions are under attack. And there is a growing willingness to sacrifice the free will of humanity for the algorithms of machine. I do not know if we will survive the next 50 years unless we are able to maintain control of our destinies."

Adam Popescu, a writer who contributes frequently to the New York Times, Washington Post, Bloomberg Businessweek, Vanity Fair and the BBC, wrote, "Either we'll be in space by then, or back in the trees. Pandora's box may finally burn us. No one knows what will happen in five years, let alone 50. It's now obvious that the optimism with which we ran headfirst into the web was a mistake. The dark side of the web has emerged, and it's come bringing the all-too-human conditions the web's wunderkinds claimed they would stamp out. Given the direction in the last five years, the weaponization of the web, it will go more and more in this direction, which ultimately means regulation and serious change from what it is now. Maybe we won't be on the web at all in that period – it will probably be far more integrated into our day-to-day lives. It's a science fiction film in waiting. With email, constant-on schedules and a death of social manners, I believe we have reached, or are close to, our limit for technological capacity. Our addictions to our smartphones have sired a generation that is afraid of face-to-face interaction and is suffering in many ways psychologically and socially and even physically in ways that we've yet to fully comprehend. This will impact society, not for the better. Manners, mood, memory, basic quality of life – they're all affected negatively."

Policy changes today will lay the foundation of the internet of tomorrow

Many respondents to this canvassing described the next several years as a pivotal time for government regulation, adjustments in technology company policies and other reforms. They say such decisions being made in the next few years are likely to set the course for digital life over the next half century. Some warn that regulation can be more harmful than helpful if its potential effects are not carefully pre-assessed.

Mark Surman, executive director of the Mozilla Foundation, responded, "I see two paths over the next 50 years. On the first path, power continues to consolidate in the hands a few companies and countries. The world ends up balkanized, organized into blocks, and societies are highly controlled and unequal. On the other path, we recognize that the current consolidation of power around a few platforms threatens the open global order we've built, and we enact laws and build technology that promotes continued competition, innovation and diversity."

Laurie Orlov, principal analyst at Aging in Place Technology Watch, wrote, "The internet, so cool at the beginning, so destructive later, is like the introduction of the wheel – it is a basis and foundation for the good, the bad and the ugly. As the wheel preceded the interstate highway system, so the internet has become the information highway system. And, just like roads, it will require more standards, controls and oversight than it has today."

Juan Ortiz Freuler and **Nnenna Nwakanma** of the Web Foundation wrote, "Allowing people to increasingly spend time in digital environments can limit unexpected social encounters, which are key to the development of empathy and the strengthening of the social fibres. In a similar way

that gentrification of physical neighborhoods often creates barriers for people to understand the needs and wants of others, digital environments can thicken the contours of these bubbles in which different social groups inhabit. In parallel, this process enables a great degree of power to be amassed by the actors that design and control these virtual environments. Whereas in the past there was concern with the power of media framing, in the future the new brokers of information will have more control over the information people receive and receive a steady stream of data regarding how individuals react to these stimuli. It is becoming urgent to develop processes to ensure these actors operate in a transparent way. This includes the values they promote are in line with those of the communities they serve and enabling effective control by individuals over how these systems operate. Government needs to update the institutions of democracy if it wants to remain relevant."

Leonardo Trujillo, a research professor in computing sciences at the Instituto Tecnológico de Tijuana, Mexico, responded, "I am worried that the digital ecosystems being developed today will limit people's access to information, increase surveillance and propaganda, and push toward limiting social interactions and organization, particularly if current policy trends continue."

Joly MacFie, president of the Internet Society's New York Chapter, commented, "Today will be seen as an inflection point – the end on the initial 'open' era, and the start of the second."

A professional working on the setting of web standards wrote, "Looking ahead 50 years, I expect that AI will either be more evenly and equitably integrated throughout societies, or that there will have been AI-driven disasters that jeopardize human and other animal life, or may have already destroyed life. On the more positive side, and focusing on medical research, I would expect AI-driven research and simulation of artificial life including cognition would have provided the tools to cure most disease, as well as to advance human capabilities through bionic augmentation. On the negative side, I would expect that AI combined with rapidly increasing capabilities of bioengineering, and with persistent socio-pathological tendencies of a small minority of the population, could have led to uncontained AI-driven cyberwarfare or biological devastation. A key determining factor differentiating these two futures might be the magnitude of social investment in a robust ethical framework for AI applications, and continued emphasis on development of a just society, with social safety nets, to help mitigate the risks of development of sociopathic behaviors that would be especially dangerous with easy access to AI."

Benjamin Shestakofsky, an assistant professor of sociology at the University of Pennsylvania specializing in digital technology's impacts on work, said, "1) The 'Uber-ization' of everything will not proceed as rapidly, nor as evenly, as many now predict. Platform companies that facilitate the exchange of goods and services will continue to confront the reality that funneling idiosyncratic human activity through digital platforms is a complicated and costly endeavor. 2) Employers will

continue to increase their use of connected technologies to monitor their workforces. However, workers will also continue to find ways to subvert employer surveillance and control. In many workplaces, employers will find it difficult to convert big data about employee activities into actionable insights. Nonetheless, legislators should act to limit the scope of employee surveillance and threats to employees' privacy."

A professor of information science wrote, "When I'm feeling dystopian, I see a world that looks a little too much like 'Mr. Robot' or 'Person of Interest,' with government or private organizations knowing too much about us and having too much control over us. I'd like to believe that interconnectivity could, instead, provide us with more ubiquitous access to information and with the ability to establish connections and deliver services across space and time."

Stephen McDowell, a professor of communication at Florida State University expert in new media and internet governance, commented, "The area of law and policy is already showing some major stresses in dealing with networked connected data systems, apart from AI systems. Law and policy is often dealt with on a case-by-case and issue-by-issue basis, treating questions and legal traditions and precedents in isolation. These issues might include speech, privacy, property, informed consent, competition and security. This has weaknesses already in a networked world where large teach firms offer platforms supporting a wide range of services and track user behavior across services…. If we add systems with more learning and predictive power to this mix, it will be important to develop new concepts that go beyond the segmented approach to law and policy we are trying to use to govern internet-based interactions presently. We need to grapple with the totality of a relationship between a user and a service provider, rather than react to isolated incidents and infringements. We need to address the trade-off between offering free services and users allowing data to be collected with minimal understanding of their consent. We should also consider stronger limits on the use of personal data in machine learning and predictive modeling. Companies that automate functions to save on input costs and to allow services to be offered at scale to reap the private benefits of innovation must also take on responsibility for unintended consequences and possibilities they have created."

Toby Walsh, a professor of AI at the University of New South Wales, Australia, said, "Like the Industrial Revolution before it, the Internet Revolution will be seen to have improved people's social, economic and political lives, but only after regulation and controls were introduced to guard against the risks."

Jonathan Taplin, director emeritus at the University of Southern California's Annenberg Innovation Lab, wrote, "The answer to this question depends totally on the willingness of regulators and politicians to rethink their ideas about antitrust policies in the digital age. If current consumer welfare standards continue to be used, the existing internet monopolies (Facebook,

Google and Amazon) will get more dominant in the AI age. They would be bigger and have more data than any government or other mediating institution. They would be beyond control. They would determine our future and politics would be of little use.... I can envision a world in which technology is a boon to human progress, but it cannot come about as long as the internet is dominated worldwide by three firms (with two Chinese competitors in Asia). It is possible that the current efforts around blockchain or the new work of Tim Berners-Lee may lead to a more decentralized web. Count me as skeptical."

Doug Schepers, chief technologist at Fizz Studio, said "The technology is less important than the laws, policies and social norms that we as a society will adopt to adapt to it."

Randy Goebel, professor of computing science and developer of the University of Alberta's partnership with DeepMind, wrote, "A challenge for an increasingly connected and informed world is that of distinguishing aggregate from individual. 'For the greater good' requires an everevolving notion and consensus about what the 'greater' is. Just like seat belt laws are motivated by a complex balance of public good (property and human costs) we will have to evolve a planet-wide consensus on what is appropriate for 'great' good."

William Dutton, professor of media and information policy at Michigan State University, commented, "We are still in a transitional period, when so much of our time and effort is focused on getting connected and using technical advances. I could imagine so many devices that complicate contemporary life, such as the mobile smartphone, disappearing as they become unnecessary for accomplishing their functions. That said, the future will depend heavily on wise policy responses, even more so than technical advances."

Luis Pereira, associate professor of electronics and nanotechnologies, Universidade Nova de Lisboa, Portugal, responded, "By virtue of the interconnection of the new tools there will be widespread data collection on people, their activities, connections, the environment and the Internet of Things. There will be increased promotion of gig-economy platforms and the focused targeting of individuals with consumerism and ideology. Unless moral values and ethical rules are put in place for application designers, product sellers, data users and autonomous software and robots, people will be forced into cluster drawers. A competitive and increasing AI race for control of profits and policies will sprout, including a digital weapons race, unless a way is found to promote collaboration instead, on the basis of regulated and overseen commitments (similar to global climate agreements) for the benefit of humanity and the planet. Certification methods for software that complies with such commitments need to be developed. People will be teaching machines how to replace themselves and others at increasing levels of cognition. Security will be a major concern. Technological developments will surpass human adaptability and raise issues we do not have the wherewithal to comprehend or address."

Hari Shanker Sharma, an expert in nanotechnology and neurobiology at Uppsala University, Sweden, said, "Technology is a tool for making life better. A goal of life is happiness, satisfaction. Both require a set of values to remain good or become evil. The internet has brought the world together. Apps are tools to perform tasks easily. The Internet of Things will connect all living and nonliving things. But the dark side of human nature – the hunger for power, possession and control that has brought wars and terrorism – cannot be corrected by the internet or apps. There is a need to identify the evil in human nature and protect the simple, good and well-meaning from becoming its prey. Evil often moves ahead of good. Perhaps it can be predicted by features that check the psychology of individuals, crime records and other past behaviors to block certain actions or warn others. Biometric identification is already used for e-security – for instance, facial recognition – and it might be possible to have bio-feature readers to detect the evil-minded or those who are likely to become evil-minded and put safety checks in place at places of danger. Expert systems for face reading, feature reading, nature reading and analysis might give warning. Trackers could be established for isolated nodes and feed details to law-enforcement agencies. No evil-monger would agree on such checks and caution, but people need to be protected from online financial fraud, rapes by social media stalkers, murders by e-system users, etc., that unchecked because no efficient warning system exists. The law today is not helpful. E-crime should be dealt with and punished without boundary. The internet needs global law and global governance to become user friendly. Global connectivity becomes a tool of criminals while those who are simply good have no power to handle evil."

Amy Webb, founder of the Future Today Institute and professor of strategic foresight at New York University, commented, "I hope historians' verdict 50 years from now will be that we made the right choice in the years 2018-2020 to rethink access to the internet, data ownership and algorithmic transparency, thus setting all of humanity on a better course for the future."

A director for an internet registry responded, "There will be ongoing radical development by which biology, at physical and molecular/genetic scales, will become integrated with digital technology. We can assume that this will be pervasive throughout society, but both the applications and the costs and conditions under which they may be accessed are unpredictable. The greatest determining factor in the overall result will be political rather than technological, with a range of outcomes between utopian and utterly dystopian."

Andrea Romaoli Garcia, an international lawyer active in internet governance discussions, commented, "The cloud is a new world and is navigating in international waters. And because it is new, laws must follow the innovation. However, I have watched all countries make laws with their minds focused on traditional models of regulation. This is wrong. Laws must be international. The interpretation of the innovation scenario should be applied by introductory vehicles of new laws. The word 'disruptive' must be interpreted to apply to new laws. When we use old models of laws

and only we are doing changes to force fit into the new model of doing business or everyday life, we are creating a crippled creature that moves in a disgusting way. I nominated this as a 'jurisdicial Frankenstein.' This means laws that will apply to the cloud environment but will never be perfect, and legal security will be threatened."

Stuart A. Umpleby, a professor and director of the research program in social and organizational learning at George Washington University, wrote, "The Congressional Office of Technology Assessment was eliminated by Newt Gingrich in order to put companies, rather than Congress, in charge of technology. Given unrestrained advancements in digital and biological technology, we now need such an office more than ever."

Divina Frau-Meigs, professor of media sociology at Sorbonne Nouvelle University, France, and UNESCO chair for sustainable digital development, responded, "Currently there is no governance of the internet proper. Cases like Cambridge Analytica are going to become more and more common. They will reveal that the internet cannot be entrusted uniquely to monopoly corporations and their leaders who are not willing to consider the unintended consequences of their decisions, which are mostly market-competition-driven). A global internet governance system needs to be devised, with multi-stakeholder mechanisms, that include the voices of the public. It should incorporate agile consultations on many topics so that individuals can have an influence over how their digital presence can affect, or not, their real life."

Jennifer J. Snow, an innovation officer with the U.S. Air Force, wrote, "The internet will continue to evolve in surprising ways. New forms of governance, finance and religion will spring up that transcend physical Westphalian boundaries and will pose challenges to existing statebased governance structures. The internet will fracture again as those founders who seek to return it to its original positive uses establish and control their own 'walled gardens,' inviting in only a select few to join them and controlling specific portions of the Net separately from nation-states. New policy and regulations will be required to address these changes and the challenges that come with them. New types of warfare will arise from internet evolutions but also new opportunities to move society forward together in a positive manner. States will no longer have the premium on power and nonstate actors, corporations and groups will be able to wield power at the state, national and regional level in new and unexpected ways. It will be a disruptive time and dangerous if not navigated smartly but may also result in some of the greatest advances yet for humanity."

Peng Hwa Ang, professor of communications at Nanyang Technological University and author of "Ordering Chaos: Regulating the Internet," commented, "We know that the future is not linear, which means that to be accurate I will be painting with broad brush strokes. 1) Laws – It is finally being recognized that laws are essential for the smooth functioning of the internet. This is a sea change from the time when the internet was introduced to the public more than 20 years ago. In

the future, governments will be increasingly feeling empowered to regulate the laws to their own political, cultural, social and economic ends. That is, countries will regulate the internet in ways that express their own sovereignty. There will be a large area of commonality. But there will also be a sizable area where the laws diverge across borders. 2) Within 50 years, there should be one common trade agreement for the digital economy. It is difficult to see China carrying on its own terms. Instead, it is more likely that China will allow foreign companies to operate with little censorship provided that these companies do not 'intrude' into the political arena. 3) It is difficult to see Facebook continuing to exist in 50 years. 4) The harm from being always on will be recognized, and so users will spend less time online. Some of the time currently spent by users will be taken over by AI bots."

Devin Fidler, futurist and founder of Rethinkery Labs, commented, "Over the last 50 years we have built a basic nervous system. Now, the challenge is to evolve it to best support human society. A great place to start is with the *many* positive and negative externalities that have been documented around network deployment. Simply amplifying the positive benefits to society for network activity and curbing network activities that impose an unfunded burden on society as a whole may be a great framework for creating a networked society that lives up to the enormous potential these tools unlock. Expect increased regulation worldwide as societies struggle to balance this equation in different ways."

David A. Banks, an associate research analyst with the Social Science Research Council, said, "The character and functionality of the internet will continue to follow the political and social whims of the major power players in the industry. If these companies continue to engage in monopolistic practices without competent and reflective regulation, then we can expect an ossified and highly commercialized digital network. If something major changes then we can expect something radically different."

Luis German Rodriguez Leal, teacher and researcher at the Universidad Central de Venezuela and consultant on technology for development, said, "The new internet will be blended with human-machine interfaces, AI, blockchain, big data, mobile platforms and data visualization as main-driven technologies. They will set up a robust and widely accessible Internet of Things. On the other hand, these will imply a disruptive way of facing everyday activities such as education, government, health, business or entertainment, among many others. Therefore, innovative regulation frameworks are urgently required for each of them."

Julian Jones, a respondent who provided no identifying details, said, "Data security will be vital as is privacy. It is essential that individuals can have more control over the context in which their data is used. In the absence of this legislation the consequences for society could be catastrophic."

Fred Baker, independent networking technologies consultant, longtime leader in the Internet Engineering Task Force and engineering fellow with Cisco, commented, "I suspect that the expansion of telephone technology and law will inform this discussion. The United States' 1934 Communications Act was designed to tame a regulated monopoly carrier and prevent the worst of what that carrier might do with the technology at its disposal. Over the past few decades, the Federal Communications Commission has tried to interpret the internet through the lens of that regulation. That has failed, for the most part, for at least two reasons. First, the internet is not a regulated monopoly. It *is* a set of companies trying to accomplish various things, some of which (notably Google, Facebook and their kin) have become very powerful and may require appropriate regulation or regulatory action to steer in the public interest. A law designed to regulate a monopoly, and experience with it, may inform a future law, but is not a substitute for it. Second, the FCC [Federal Communications Commission] tries desperately to understand the internet to be one two things: a way to carry messages from ingress to egress without inspecting or changing them (a telecom service), or a way to access an application (an information service). It is neither, and it is both. Until we have a law that can follow that difference in service model in the internet, we will find differences between the internet as implemented and the internet as regulated."

Jennifer Jarratt, owner of Leading Futurists consultancy, commented, "We need new regulation now that can protect users and the digital world from themselves and itself. With those we could also have a fully digital government that might be able to handle some of the planet's big problems. Expect also new activism and new social orders. In the next 50 years, technological change will produce significant change – but maybe not as much as we expect or would like. The world will have become more difficult to live in by then, so we'd better hope tech has some answers."

Oscar Gandy, emeritus professor of communication at the University of Pennsylvania, responded, "The whole notion of connectivity is bound to be redefined in the not-too-distant future. When we extend the processes through which miniaturization married with processing speed, and divorce from personal device-based memory, the possibilities for connectivity/interactivity/control, and what we mean by intelligence are beyond the ability of any but authors of science fiction novels (I guess that excludes those among us who consider themselves to be 'futurists'). I think the most interesting possibilities are those that actually eliminate (or seem to eliminate) the need to possess devices to make use of what we currently refer to as connectivity. This means that all we need is access to the intelligent network – a level of access that will not require manual action of any kind; I can even imagine that use of this network will not even depend upon requests made vocally – thought will be enough. So, I don't know what the requisite 'interface' will be, but I believe that something akin to sensors interacting with implanted chips will be commonplace, without the chips, with sensing of the brain from what we would characterize as a reasonable conversational distance from the sensor(s) would be sufficient. Of course, for a privacy scholar, this is quite a leap from our present thinking about access to and

control over our private thoughts. This will, therefore, be an area of much work with regard to law, regulation and control of these developments and their use by others for specified legitimate purposes."

Jennifer King, director of privacy at Stanford Law School's Center for Internet and Society, said, "The last 10 years have demonstrated the risks with unleashing the internet on society with little accounting for public responsibility. I predict in Western democracies, we will see a greater push for more regulation and corporate responsibility for the effects of technology. In totalitarian states, we will see concentrated social control through technology. And across the board, I suspect it will become increasingly difficult to live a life outside of the reach of technology."

Tracey P. Lauriault, assistant professor of critical media and big data in the School of Journalism and Communication at Carleton University, commented, "We are already seeing platform convergence and the resale of platform data to third parties with whom we do not have a direct relationship. We already know that data brokerage firms are not regulated and there is very little regulation when it comes to credit scoring companies. In addition, we are already beginning to see erroneous social science hiding behind algorithms, not unlike what we saw at the beginning of the Enlightenment, and we have not even begun to address the social-technical and political outcomes of junk AI/social sciences (i.e., finding gay people or criminals in facial recognition – harkening on the bad old days of eugenics and skull measuring). The European Union's General Data-Protection Regulation on the right to access information will help, but, for the moment, there is little individual and aggregate protection. Also, will private sector companies who aggregate, buy and sell our data, who create individual data shadows or data doppelgangers that become our representatives in this data world, know more about us than we know about ourselves? What influence will they have on larger political decision-making? Decision-making over our lives? How do we correct these systems when they are wrong? How do we adjudicate and context egregious 'data-based decisions' in the courts with current intellectual property law? And what of personal sovereignty and state sovereignty? What of other decision-making systems such as social scores in China? How with the poor, elderly and disabled be protected from automated decision-making about social welfare and supports if they do not have assurances that the decision-making about them are correct? And what of junk coding that persists and does not get removed and just keeps generating bad decisions? Who audits? Who is accountable? And will these become the new governors? The future is here and we do not know how to deal with it. The EU is beginning to address these and holding these companies to account, but our citizens in North America are not as well versed, and arguably, our governors seem generally less interested in our well-being, or perhaps are more ignorant of the implications."

Andreas Kirsch, a fellow at Newspeak House, formerly with Google and DeepMind in Zurich and London, wrote, "Regulation will force open closed platforms. Information will flow more

freely between services. Internet services will become more decentralized again as network bandwidths will not be sufficient for the data volumes that users will produce by then. Applications and services will not be coupled to devices anymore but will follow us freely between different contexts (shared car, home, work, mobile devices)." **Anonymous respondents** said:

- "It is not about the technology itself … it is about the lack of regulation by the institutions and their lack of understanding of the general public."
- **"**With each advance there are concerns about privacy and political abuses and these will need to be addressed with technology and with innovation in policy and laws."
- "The executives of Facebook will be indicted and their trial will begin the process of reform. Once we get over the idea that tech executives can commit heinous crimes and we hold them accountable, the tech world will begin the process of change."

Internet everywhere, like the air you breathe

When asked to look ahead to 2069, respondents largely agreed that connectivity will be both more pervasive and less visible. A large share predicted that humans and networked devices will communicate seamlessly and the concept of "going online" will seem archaic. They anticipate that the internet will "exist everywhere," turning planet Earth into a cybersphere where connectivity is as natural as breathing.

Alf Rehn, a professor of innovation, design and management in the school of engineering at the University of Southern Denmark, commented, "The curious thing will in all likelihood be how unaware we'll be of the internet in 50 years. Today, the only time we really reflect on electricity and plumbing is when they break down. At other times, they're just there, as self-evident as air. I believe we will look to digital tools in much the same way. We walk into a room and turn on our digital streams much like we turn on a light. We wonder how much money is in our bank account, and just ask the air, and the wall replies ('You're slightly overdrawn. Shouldn't have bought those shoes. I told you.'). We start cooking, and our kitchen gently suggests we stop doing the Thai fish stew, because we forgot to tell the kitchen we wanted to do that, so it hasn't ordered fresh lemongrass. We'll do a Mediterranean trout dish instead. The only time we reflect over any of this is when the Net, for whatever reason, cuts out. It usually lasts only a few minutes, but for those minutes we become like children, stumbling around unsure what to do when not surrounded by endlessly helpful technology."

Scott Burleigh, software engineer and intergalactic internet pioneer, wrote, "Machine-tomachine network communications will become ubiquitous, and computing hardware will have access to all

human information; to the extent that hardware becomes intelligent and volitional it will replace humans in essentially all spheres. Humans' ability to benefit from this advance will be limited mainly by our inability to come up with adequate interfaces – graphical user interfaces are a dead end, voice is simply annoying and nobody types fast enough. The hardware will know everything and won't be able to convey it to us."

Adam Powell, senior fellow at the University of Southern California Annenberg Center on Communication Leadership and Policy, wrote, "Predicting 50 years out is inherently risky (see all of those flying cars overhead?). But, barring a catastrophe – epidemic, war – extrapolating from recent history suggests the internet will become more pervasive, more powerful and less expensive. Think of electricity, or electric motors; they are ubiquitous, noticed mainly when they cease to function."

John Laird, a professor of computer science and engineering at the University of Michigan, responded, "The internet infrastructure will disappear from public view. It will be ubiquitous, always on, always available and invisible. Access will be worldwide. What will change will be our means of interacting with it. Augmented reality will be ubiquitous (much sooner than 50 years), with essentially everything interconnected, including the human body – and possibly the human mind. There are many risks, and many ways in which ubiquitous connectivity can and will be abused, but overall, it will enhance people's lives. We will go through ups and downs, but there will be significant advances in security."

A senior data analyst and systems specialist expert in complex networks responded, "This is an area where I think a few science fiction writers, such as John Brunner, have seen the future. The future version of the internet will be more ubiquitous and more seamless (building on the Internet of Things), but it will also be much less secure, with people suffering damage from various kinds of hacking on a daily basis. However, this lack of security will gradually become the 'new normal,' and the outrage will fade."

Nigel Hickson, an expert on technology policy development for ICANN based in Brussels, responded, "I do not think we will be talking about the internet in 50 years' time. As the internet becomes ubiquitous it is simply an enabling force like air or water; it's what we do with it that becomes more important – is the power used for good, to improve society, enhance freedom and choice, or is it used to enslave? The internet cannot be divorced from the progress of society itself. In an enlightened democracy the effect of the internet will have been positive, enhancing freedom and choice, but in a dictatorship the opposite could well be true."

From the 'Internet of Things' to the 'Internet of Everything'

In 1982, graduate students in the computer science department at Carnegie Mellon University connected a Coke vending machine to the ARPANET, creating the first "smart device." The rise of networked devices, collectively known as the "Internet of Things," was a dominant theme in the 2014 Pew Research Center-Imagining the Internet report on the Impacts of the Internet by 2025. When asked four years later to look ahead to 2069, these expert respondents predicted the further rise of networked devices and extended the concept to include the technical hybridization of the natural world.

Edson Prestes, a professor and director of robotics at the Federal University of Rio Grande do Sul, Brazil, wrote, "I believe the internet will no longer exist in the way we see today. It will not be possible to see the internet as a huge network of connected devices, but instead it will be something unique that works in a pervasive and transparent way – like air that exists everywhere so we forget about its existence. We will use the environment to transmit information, via plants, soil, water, etc. We will develop new processes to take advantage of all resources available in the environment, e.g., we might use biochemical processes of plants to give support to data processing. Humans will be naturally adaptable to this pervasive environment. Some people will use prostheses to get/transmit/visualize and process information, maybe plugged directly in the brain and working in unison with the brain lobes. The information received from the environment can be seen as a 'new sensory input.' Thus, all interfaces and tools will be totally reshaped: no mouse, no menus, no 'blue screens of death.' Others, from the 'old school,' will use plug-and-play wearable gadgets."

Valarie Bell, a computational social scientist at the University of North Texas, commented, "In the coming decades, we'll have one 'device' if any at all. Everything will be voice-print-activated and/or bio-scanner-activated (retinal scan) so passwords and login details become irrelevant. This will make identity theft more difficult but not impossible, as no matter what system or technology people create, other people will immediately develop ways to deviate or breach it. All domiciles' powered devices will likely be solar-powered or powered in a way other than 20th century electricity. Personal credit cards, driver's licenses and other portable documentation that you'd carry in your wallet would become synced to a single cloud-based account accessible via bioscannable systems. To buy groceries, simply use your home grocery 'app' to open your account as your pantry, freezer, and fridge order what you're out of. Then robots will pack your order and self-driving cars with robot delivery staff will restock your kitchen. Later, groceries will appear in your kitchen in much the same way Capt. Kirk and Mr. Spock used to beam up to the Enterprise on 'Star Trek.' Instead of you teaching your young children to read, tie their shoes, do their homework or clean their room, aids like Alexa that are more developed and can operate in multiple rooms of the house will do those things. People continue to abdicate their duties and responsibilities to devices and machines as we've become more selfish and self-obsessed. Social networking sites like Facebook will be holographic. People will likely have one or more implants to allow them to access

the internet and to access whatever the future computer will be. People won't type on computers. Perhaps you'll be able to think what you want to type and your system will type it for you while you eat lunch, watch TV, walk in the park or ride in your self-driving car. It's also important to remember that past projections from 50 years ago never predicted the internet but did predict lots of technology that even now we still don't have. So we can expect the same with our predictions."

Stephen Abram, principal at Lighthouse Consulting Inc., wrote, "We will be well beyond apps and the web in 50 years. The networked information, entertainment and social world will be fully integrated into biology and networked appliances (not toasters but a full range of new appliances that may be stand-alone like Google Home but are more likely fully integrated devices into architecture and spaces)."

Lee McKnight, associate professor, School of Information Studies, Syracuse University, commented, "The internet will reach close to 100% of humans, forests, fields and streams, as well as most non-human species, in 2069. The Internet of Things will grow to trillions of things – and all factories, cities and communities…. I do expect pop-up networks will permit people even in the most remote locations, or communities with limited means, to access and share services and internet bandwidth from literally anywhere on this planet, as well as from our Mars colonies and moon bases. What, you thought there would be just one? Forecasting the way we interact with software and hardware is too limited a starting point, as we must assume biochemistry (wetware) will also increasingly take its place in human-machine interaction environments and platforms. While science fiction is comfortable imagining all kinds of scenarios, the future-realist in me can only see good, bad and ugly wetware interacting with all of us, at all times, in 2069."

Mícheál Ó Foghlú, engineering director and DevOps Code Pillar at Google, Munich, said, "Looking forward 50 years is almost impossible. I think the biggest trend we can anticipate from today's frame is that the huge increase in machine-to-machine intercommunication, the Internet of Things, will transform the landscape. This will mean all electronic devices will have some form of built-in intelligence and many systems will layer on top of this massively interconnected intelligent mesh."

Peter Eachus, director of psychology and public health at the University of Salford, UK, responded, "The most fundamental change will be the way in which we interact with this connected technology. There won't be tablets or smartphones or screens. We will be able to just think of a question and the answer will immediately come to mind! The Mindternet is the future!"

A professor and director at a major U.S. university said, "While the Internet of Things will be touted as time-saving and labor-saving it will present additional challenges due to distraction and reduce the quality of intrapersonal relations in addition to adding security vulnerabilities."

A member of the editorial board of the ACM Journal for Autonomous and Adaptive Systems commented, "I envision billions of devices, objects locally interacting with each other, learning from their activities, usages and users' feedback and providing instant, on-demand services not pre-coded or pre-designed. These services are the result of collective interactions happening locally with no central servers. Ethics and privacy [are] granted by default. When a user's request or need cannot be met, devices/objects provide themselves the missing software (self-coding) or request any missing hardware."

Additional **anonymous respondents** said they expect:

- "We will be much less aware of the internet because it will be mostly seamlessly woven into our everyday lives."
- "A total integration of human inputs (perceptions) and outputs (actions) with the internet and the objects and tools around them."
- "Free internet access worldwide will be regarded as a basic human right."
- "People will be seamlessly and continuously interconnected without having to use a device of any kind."
- "Everything will be stored in cloud storage. Sensors will be everywhere, from parking lots to agricultural fields."
- "More and more of our spheres – even our bodies – will be more and more integrated into the network."
- "There will be a cashless society. E-shopping will dominate people's lives. The Internet of Things will become a part of us – embedded, for instance, in clothes, thermoses, heating systems, etc."
- "Due to the lack of transparency and understanding of algorithmic systems and their owners, humans' individual autonomy and agency is going to decrease."
- "More connected objects and connected experiences will allow to get over the digital divide and allow everyone to profit from the digital lifestyle. At the same time advances in green tech will also allow the connectivity not to be made at the expense of the environment."
- "Your report card could be connected to, say, a restaurant's app which will make reservations for you when you get good grades."

It will be impossible to unplug

A share of respondents explored the possibilities and challenges of living in a fully networked world where it is difficult, or even impossible, to disconnect. The following comments illuminate some of their expectations in the future of constantly connected life.

Steven Polunsky, director of the Alabama Transportation Policy Research Center, University of Alabama, said, "We all know where this is going. We are at the earliest stages of making devices like electric and water meters 'smart' and integrating home accessories with internet functionality. The issue is whether people will be allowed, by regulation or by practical exercise, to opt out, and what the effects of that action will be, as well as what efforts will be required to bring services to those at the fringes. Does government have an obligation, such as led to the creation of the Rural Electrification Administration or Essential Air Service, that extends to the requirement or provision of broadband and beyond to the services it enables?"

Helena Draganik, a professor at the University of Gdansk, Poland, responded, "The rules/law of internet communication will be unified between many countries, which will limit the freedom of expression. There will grow to be even more dependence upon big platforms (e.g., Facebook) and a deepening of the monetization of our customs and habits. The marketing industry will grow. The internet will just be one more, marketing-dependent medium – as press or TV. Yes, in the future there will be many information technology and artificial intelligence applications and commodities to simplify our lives. But it is possible that we will not be able to function properly without them."

An expert on converging technologies at for a defense institute wrote, "The internet 50 years from now will look nothing like it does today. Physical infrastructure will be entirely pervasive and wireless (perhaps non-electronic) and digital elements will be directly interfaced with human brains. And the minds of different individuals may be directly linked. This will be a new era for humankind, which is difficult to hypothesize about."

Christopher Yoo, a professor of law, communication and computer and information science at the University of Pennsylvania Law School, responded, "If I had to predict (and undertake the concomitant risk and inevitable likelihood that some of these predictions will turn out to be wrong), I would expect more users to become increasingly reliant on their mobile devices and to rely on them for mobile payments and other functions. Just as cloud computing disintermediated PC operating systems and created new key intermediaries, such as hypervisor leader VMWare, these new functions will shake up existing industries and inevitably displace incumbents that are too slow to innovate."

Nancy Greenwald, a respondent who provided no identifying details, wrote, "I started on the early internet in 1983-84 on 'Dialog,' with a dial-up connection. Now I talk with my devices, giving instructions, dictating, etc. What I expect to see is a growing number of tasks we can complete through the internet, continual increases in collaborative platforms with an increase in a greatly improved 'open API' type of program integration, and an increase in the ways we connect with the technology (our wearable technology is crude) so that we are continuously connected. I already

have the feeling that one of my senses is cut off when I am unable to connect to the internet. I expect that sense of enabling/dependence to increase."

A well-known writer and editor who documented the early boom of the internet in the 1990s wrote, "We will take omniscience over the state of the world for granted because we will be connected to everything, always. We are therefore all the more likely to be distracted from asking questions that really matter. On balance, greater knowledge leads to greater happiness – though there is a lot of distraction to get through along the way."

A professor of electronic engineering and innovation studies who is based in Europe commented, "A radical change will occur in the way the people see human-machine and humanhuman interactions. Humans will be entirely dependent on information systems, just like our generation got used to being dependent on electricity or transport systems. Also, expect radical innovations in neural connection (i.e., human brains integrated with computers). The effects of this remain highly unpredictable."

Slowing the pace of internet innovation

Although a significant majority of survey respondents expected the rate of technological advancement to remain steady or increase in the next 50 years, a vocal minority argued that humanity may be entering a cooling-off period when it comes to digital evolution.

Lee Smolin, a professor at Perimeter Institute for Theoretical Physics and Edge.org contributor, responded, "Many technologies evolve fast until they reach functional maturity, after which how they function for us evolves slowly. I suspect the internet has already reached, or will shortly reach, that state."

Ken Birman, a professor in the department of computer science at Cornell University, responded, "Technology booms take the form of 'S' curves. For any technical area, we see a slow uptake, then a kind of exponential in which the limits seem infinite, but by then things are often already slowing down. For me, the current boom in cloud computing has created the illusion of unbounded technical expansion in certain domains, but in fact we may quickly reach a kind of steady state. By 2050, I think the focus will have shifted to robotics in agriculture and perhaps climate control, space engineering, revolutionary progress in brain science and other biological sciences. This is not to say that we will cease to see stunning progress in the internet and cloud, but rather that the revolutions we are experiencing today will have matured and yielded to other revolutions in new dimensions they will surely leverage the network, but may no longer be quite so network-centric."

Zoetanya Sujon, a senior lecturer specializing in digital culture at University of Arts London, commented, "Based on the cyclical histories of the printing press, telephone, internet, virtual reality and artificial intelligence, I believe that all technologies are subject to waves, often characterized by ferment/early development, great claims and excitement whether positive or negative, and if they reach the mainstream, they will also experience an era of maturity marked by institutionalization and 'an era of dominant design.' After this point, technologies are likely to become obsolete, adapt or converge, or follow through incremental change – all rather like knowledge and product cycles."

A lead QA engineer at a technology group said, "Twenty years ago someone told me that in the future all of our applications and data would be online. I did not believe it … and here we are today. The advances in technology are based on continued availability of electricity that makes technology and connectivity possible. I have a feeling that while many advances are made, some in our society will want to separate themselves. Like in the 1950s the big thing was canned goods, instant meals, and now 50 years later many are going back to cooking from scratch."

An internet pioneer wrote, "If history is a guide, the 10 most valuable companies in the world will be different 50 years from now than they are today. These new players will have succeeded in re-centralizing something that earlier generations had de-centralized. Perhaps we return to desktop/mobile phone single-vendor dominance. Combined with human-computer interfaces, the prospect of single-vendor control over the operating system of a substantial portion of your brain is rather frightening. As to the core internet itself – I suspect it won't actually change a lot. Just like railroads or highways, infrastructure sees short periods of time of great innovation, and then a long plateau. I don't think the internet has seen much change in the last 10 years aside from being bigger, colder, harsher and filled with more bad actors, so I suspect that plateau will continue more or less for another 50."

A principal researcher for one of the world's top five technology companies commented, "What technology makes possible in 50 years depends on what technology exists in 50 years. Will Moore's Law and related semiconductor accelerations be extended through quantum, optical, or some other computing? A breakthrough there in the next 20 years would lead to unimaginable consequences in 50 years. But it seems more likely that they won't, so we can expect a slow realization of the full capabilities of technology that is not qualitatively different from today's. That leaves substantial room for increased capability as cloud computing and the Internet of Things get worked out with modest assists from data science and machine learning, and as our attentional balance shifts from novelty and eye-catching visual design to utility and productivity."

Visions of the future: 'Brave New World,' '1984' or 'The Jetsons'

A number of respondents shared colorful descriptions of what they expect the world might look like in 2069.

Garland McCoy, founder and chief development officer of the Technology Education Institute, wrote, "On the first day there was analog voice and, behold, it was good. On the second day there was human-generated data/content, and it was pleasing to the people. On the third day machines began to talk directly to machines and this was seen as excellent indeed. On the fourth day, machines began to design their own network of networks (e.g., LoRaWAN, a device-to-device architecture), and behold great efficiency spread out upon the land. On the fifth day humans began to leave their homes and assemble at the town square to talk among themselves face-to-face and this brought great joy to the multitudes. On the sixth day, just as the wise men from the Semiconductor Industry Association had predicted, the world was unable to generate enough electricity to feed all of the chips/devices the wise men had created and darkness descended upon the land. On the seventh day the people rested because that was all they could do. And so endeth the lesson."

Baratunde Thurston, futurist, former director of digital at The Onion and co-founder of the comedy/technology startup Cultivated Wit, wrote, "With land and servers, Amazon was able to accelerate the merger of the space formerly referred to as 'the internet' and the realm once called 'meatspace,' or 'in real life,' such that there is no longer a distinction – it is all referred to now as 'The Prime Network.' … Once it was proven in 2045 that a hybrid human-networked intelligence could manage and draft legislation far better than inconsistent and infinitely corruptible humans, the U.S. Congress was replaced with a dynamic network model accounting for the concerns of citizens yet bound by resource constraints and established laws. This happened too late to save Miami, which is now only accessible by automated submarine, historical tours or VR re-creations, but it did help rally the resources required to halt The Ten-Year Burn in California and restore much of Lower Manhattan. Americans now spend roughly 30 percent of their waking hours in SR (simulated reality) environments. Many spend this time reliving revised personal histories which make them the most popular students in high school even though industrial school farms were abolished 25 years ago and replaced by personalized Mental Training Plenaries that dynamically adjusted to the learning styles and needs of each student. Another 20% of waking hours are spent passively consuming immersive narratives customized to each person. In order to maintain social cohesion, however, these personalized narratives have overlapping characters, plot points and themes so that people have something to talk about when they encounter their fellow humans. Americans split the rest of their time between eating, picking up litter and serving on the obligatory Algorithmic Oversight Committees. Advertising has been banned. Once we launched the 360 Accounting Project to measure the impact of nearly all human endeavors and score them on various elements, the practice of advertising was found to have a negative social, financial, emotional, ecological and moral return on investment. Any human or hybrid engaged in

advertising is disconnected from The Prime Network for six hours on a first offense, one day for a second offense and permanently for a third offense. Amazon is exempt from the advertising ban per the Terms of Service that govern all Prime citizens."

Jamais Cascio, research fellow at the Institute for the Future, wrote, "I imagine three broad scenarios for AI in 50 years. No. 1, EVERYWARE, is a crisis-management world trying to head off climate catastrophe. Autonomous systems under the direction of governance institutions (which may not be actual governments) will be adapting our physical spaces and behaviors to be able to deal with persistent heat waves, droughts, wildland fires, category 6 hurricanes, etc. Our routines will be shaped by a drive to a minimal footprint and a need to make better longer-term decisions. This may not be 'green fascism' precisely, but that will be a common invective. The dominant design language here is *visible control* – of public spaces, of economic behavior, of personal interactions, etc. AI is a climate-protective Jiminy Cricket with an attitude. No. 2, ABANDONWARE, is also crisis-driven, but here various environmental, economic and political crises greatly limit the role of AI in our lives. There will be mistrust of AI-based systems, and strong pushback against any kinds of human-displacement. This likely results from political and economic disasters in the 2040s-ish linked to giving too much control to AI-based systems: institutional decisions driven by strategies to maximize profits and control, while minimizing uncertainty and risk. AIs messing around with elections, overriding community decisions and otherwise pushing aside fuzzy emotional thinking with algorithmic logic goes swiftly from being occasionally annoying to infuriatingly commonplace. The dominant design language for AI here is *submissive*. AI is still around, but generally whimpering in the corner. No. 3, SUPERWARE, is the world described in the first answer (AI common but largely invisible) turned up to 11. In this scenario, AI systems focus on helping people live well and with minimal harm to others. By 2069, the only jobs performed by humans in the post-industrial, post-information world require significant emotional labor, unique creative gifts or are simply done out of the pleasure of doing them. The newly developed world is still adapting, but what amounts to the end of 19th century industrial capitalism forces this change. AI-based systems are dealing with climate, global health, and the like, but in ways meant to increase human well-being over the long term. Most people born before 2020 *hate* this, seeing it as 'robo-nanny state socialism' and 'undermining human dignity' even as they take advantage of the benefits. The dominant design language for AI here is 'caring.' Machines of Loving Grace, whether you like it or not."

Ebenezer Baldwin Bowles, author, editor and journalist, responded, "The next 50 years? A time frame ending in 2069? As grandpa would say, 'I can't imagine.' But we must try or else fall silent. 1) The best and brightest will communicate brain-to-brain through implants linked to synapses altered by quantum surgery. Encrypted and delivered by carbon-silicone hybrid technology, this radical expression of the desire to communicate will create new systems of power and control by the planet's ruling class. 2) Global nation-states, empowered by iron-fisted control

of electronic media and financial systems, protected by police drones and robots through continuous surveillance systems, and sustained by a willing populous, will oversee legions of workers dedicated to the maintenance of the ruling class of the 1%. 3) The development of no-cost neighborhood-based replicator stations will provide unlimited access for everyone to nutritious food, comfortable clothing suitable to local climates, every imaginable item necessary to maintain a household, and personal necessities linked to popular concepts of comfort and entertainment. The replicator system, an advanced expression of today's 3D printing technology, will serve as a means of control of the working and professional classes – a chicken in every pot times 10. So, robots and drones with the Evil Eye to watch and control the people. Unlimited food, clothing and shelter to cow the masses into happy servitude. Total reliance on AI and its tendrils to supply the necessities of life. What a wonder to behold in 2069. Think back to 1969. Even the most imaginative thinkers missed the one crucial aspect of digital control of everyday life in 2018: the surveillance camera. Who back then could imagine the total loss of privacy and personal independence we live with today? We are swallowed up by digital influences now. In 50 years the influences shall morph into total control, and the world we know now shall be devoured by electric ones and zeroes, one after another in the rapid march to dissolution."

Jerry Michalski, founder of the Relationship Economy eXpedition, said, "Most internetconnected devices have been p0wn3d and are in the Dark Net, making most systems scary and unstable. Super-small drones changed warfare and policing, making it difficult and expensive to hide. Anyone who feels at risk travels in a self-sufficient chamber to avoid infiltration. Meanwhile, a quarter of humanity has figured out how to hear one another and live in abundance, but they have to keep below the radar…. Over 50 years many more things will change, but the forces at play are shoving society in negative directions. People who want better will achieve progress, but I see a dystopian future for the majority of humanity."

A research scientist who works for Google said, "You want a 50-year prediction? I'm not sure what to say. Google is only 20 years old – would you have predicted that (and all of the side effects) back in 1968 (50 years ago)? Likewise, Amazon is 24 years out. My point is that predicting tech changes in the online/software space is really, really hard. Remember the rise (and fall, and rise?) of walled gardens? Did anyone predict the fall of AOL back when it was the biggest company around? A few things I can predict with confidence: 1) There will be new business models that we do not yet know about. Amazon was enabled by a host of technologies that didn't exist in 1968. Play that same tune forward. 2) There will be a backlash against the Internet of Things. Just sayin'. 3) Eventually, we'll figure out how to do sufficiently high frame-rate and precision registration so that VR/AR actually works. Both will be interesting; both have the possibility of being worldchangers. (But I don't know how that will happen yet. Probably, it will happen in a way we don't yet understand.) 4) Bandwidth will eventually make it into the entire third world. *That* will change the online landscape as much as when the ARPANET became open for commercial

purposes. (That is, dramatically.) 5) The social effects of connectivity (especially in the third world) + bandwidth + radicalized pockets of folks will make the current internet battles seem tame. AI will be important, but it's not going to be the big driver."

The chief marketing officer for a technology-based company said, "The Internet of Things and AI will exponentially help to automate and organize society and the world at large by enhancing existing infrastructure and innovating new ones."

An anonymous respondent wrote, "Widespread networked computing will have collapsed 50 years from now, as will society."

4. The internet will continue to make life better

A large share of respondents predict enormous potential for improved quality of life over the next 50 years for most individuals thanks to internet connectivity, although many said the benefits of a wired world are not likely to be evenly distributed.

Andrew Tutt, an expert in law and author of "An FDA for Algorithms," said, "We are still only about to enter the era of complex automation. It will revolutionize the world and lead to groundbreaking changes in transportation, industry, communication, education, energy, health care, communication, entertainment, government, warfare and even basic research. Self-driving cars, trains, semi-trucks, ships and airplanes will mean that goods and people can be transported farther, faster and with less energy and with massively fewer vehicles. Automated mining and manufacturing will further reduce the need for human workers to engage in rote work. Machine language translation will finally close the language barrier, while digital tutors, teachers and personal assistants with human qualities will make everything from learning new subjects to booking salon appointments faster and easier. For businesses, automated secretaries, salespeople, waiters, waitress, baristas and customer support personnel will lead to cost savings, efficiency gains and improved customer experiences. Socially, individuals will be able to find AI pets, friends and even therapists who can provide the love and emotional support that many people so desperately want. Entertainment will become far more interactive, as immersive AI experiences come to supplement traditional passive forms of media. Energy generation and health care will vastly improve with the addition of powerful AI tools that can take a systems-level view of operations and locate opportunities to gain efficiencies in design and operation. AI-driven robotics (e.g., drones) will revolutionize warfare. Finally, intelligent AI will contribute immensely to basic research and likely begin to create scientific discoveries of its own."

Arthur Bushkin, an IT pioneer who worked with the precursors to ARPANET and Verizon, wrote, "Of course, the impact of the internet has been dramatic and largely positive. The devil is in the details and the distribution of the benefits."

Mícheál Ó Foghlú, engineering director and DevOps Code Pillar at Google, Munich, said, "Despite the negatives I firmly believe that the main benefits have been positive, allowing economies and people to move up the value chain, ideally to more rewarding levels of endeavor."

Perry Hewitt, a marketing, content and technology executive, wrote, "On an individual basis, we will think about our digital assets as much as our physical ones. Ideally, we will have more transparent control over our data, and the ability to understand where it resides and exchange it for value – negotiating with the platform companies that are now in a winner-take-all position.

Some children born today are named with search engine-optimization in mind; we'll be thinking more comprehensively about a set of rights and responsibilities of personal data that children are born with. Governments will have a higher level of regulation and protection of individual data. On an individual level, there will be greater integration of technology with our physical selves. For example, I can see devices that augment hearing and vision, and that enable greater access to data through our physical selves. Hard for me to picture what that looks like, but 50 years is a lot of time to figure it out. On a societal level, AI will have affected many jobs. Not only the truck drivers and the factory workers, but professions that have been largely unassailable – law, medicine – will have gone through a painful transformation. Overall I am bullish in our ingenuity to find a higher and better use for those humans, but it seems inevitable that we'll struggle through a murky dip before we get there. By 2069, we'll likely be out the other end. My biggest concern about the world 50 years out is the physical condition of the planet. It seems entirely reasonable that a great deal of our digital lives will be focused on habitable environments: identifying them, improving them, expanding them."

David Cake, an active leader with Electronic Frontiers Australia and vice chair of the ICANN GNSO Council, wrote, "Significant, often highly communication and computation technologically driven, advances in day-to-day areas like health care, safety and human services, will continue to have a significant measurable improvement in many lives, often 'invisible' as an unnoticed reduction in bad outcomes, will continue to reduce the incidence of human-scale disasters. Advances in opportunities for self-actualisation through education, community and creative work will continue (though monetisation will continue to be problematic)."

Eugene H. Spafford, internet pioneer and professor of computing sciences at Purdue University, founder and executive director emeritus of the Center for Education and Research in Information Assurance and Security, commented, "New uses, information sources and paradigms will improve the lives of many. However, the abuses, dilution of privacy and crime will also make things worse."

Jeff Jarvis, director of the Tow-Knight Center at City University of New York's Craig Newmark School of Journalism, commented, "One need be fairly cynical about one's fellow humans and somewhat hubristic about one's own exceptional abilities to argue that most people will act against their own self-interest to adopt technologies that will be harmful to them. This is why I am driven nuts by the contentions that we have all become addicted to our devices against our will, that the internet has made us stupid in spite of our education, that social media has made us uncivil no matter our parenting, as if these technologies could, in a mere matter of a few years, change our very nature as human beings. Bull. This dystopian worldview gives people no credit for their agency, their good will, their common sense, their intelligence and their willingness to explore and experiment. We will figure out how to adopt technologies of benefit and reject technologies that

harm. Of course, there will be exceptions to that rule – witness America's inability to come to terms with an invention made a millennium ago: gunpowder. But much of the rest of the civilized world has figured that one out."

Andrew Odlyzko, professor at the University of Minnesota and former head of its Digital Technology Center and the Minnesota Supercomputing Institute, said, "Assuming we avoid giant disasters, such as runaway climate change or huge pandemics, we should be able to overcome many of the problems that plague humanity, in health and freedom from physical wants, and from backbreaking or utterly boring jobs. This will bring in other problems, of course."

Pedro U. Lima, an associate professor of computer science at Instituto Superior Técnico, Lisbon, Portugal, said, "Most of the focus on technology and particularly AI and machine learning developments these days is limited to virtual systems (e.g., apps for travel booking, social networks, search engines, games). I expect this to move, in the next 50 years, into networking people with machines, remotely operating in a myriad of environments, such as homes, hospitals, factories, sport arenas and so on. This will change work as we know it today, as it will change medicine (increasing remote surgery), travel (autonomous and remotely-guided cars, trains, planes), entertainment (games where real robots, instead of virtual agents, evolve in real scenarios). These are just a few ideas/scenarios. Many more, difficult to anticipate today, will appear. They will bring further challenges on privacy, security and safety, which everyone should be closely watching and monitoring. Beyond current discussions on privacy problems concerning 'virtual world' apps, we need to consider that 'real world' apps may enhance many of those problems, as they interact physically and/or in proximity with humans."

Timothy Leffel, research scientist, National Opinion Research Center at the University of Chicago, predicted, "Future historians will observe that, in many ways, the rise of the internet over the next few decades will have improved the world, but it hasn't been without its costs that were sometimes severe and disruptive to entire industries and nations."

Dave Gusto, co-director of the Consortium for Science, Policy and Outcomes at Arizona State University, commented, "Fifty years is a terrifically long time for forecasting. A lot might be riding on, for example, what happens with the current conflict around net neutrality and the way that public or private interests get to shape the net from now forward. But within either pathway – public-interest dominated or private-interest dominated – the ability of some actors to enjoy the highest-end benefits and many actors to use what they can access or can manage to learn is a likely contour to the overall system. I think that a vast diversity of uses will characterize the future system, focusing on experience, entertainment and education, enhanced by AR and VR."

A representative for a Middle Eastern telecommunication directorate wrote that online life will continue to be a plus in most individuals' lives, adding, "As far as technological history is concerned, there has been no single case that the advance of technology and innovation has worsened the lives of individuals. This is similarly valid for AI."

Living longer and better lives is the shining promise of the digital age

Many respondents to this canvassing agreed that internet advancement is likely to lead to better human-health outcomes, although perhaps not for everyone. As the following comments show, experts foresee new cures for chronic illnesses, rapid advancement in biotechnology and expanded access to care thanks to the development of better telehealth systems.

Steve Crocker, CEO and co-founder of Shinkuro Inc., internet pioneer and Internet Hall of Fame member, responded, "Life will improve in multiple ways. One in particular I think worth mentioning will be improvements in health care in three distinct ways. One is significantly better medical technology related to cancer and other major diseases. The second is significantly reduced cost of health care. The third is much higher and broader availability of high-quality health care, thereby reducing the differences in outcomes between wealthy and poor citizens."

Susan Etlinger, an industry analyst for Altimeter Group expert in data, analytics and digital strategy, commented, "Many of the technologies we see commercialized today began in government and university research labs. Fifty years ago, computers were the size of walk-in closets, and the notion of personal computers was laughable to most people. Today we're facing another shift, from personal and mobile to ambient computing. We're also seeing a huge amount of research in the areas of prosthetics, neuroscience and other technologies intended to translate brain activity into physical form. All discussion of transhumanism aside, there are very real current and future applications for technology 'implants' and prosthetics that will be able to aid mobility, memory, even intelligence, and other physical and neurological functions. And, as nearly always happens, the technology is far ahead of our understanding of the human implications. Will these technologies be available to all, or just to a privileged class? What happens to the data? Will it be protected during a person's lifespan? What happens to it after death? Will it be 'willed' as a digital legacy to future generations? What are the ethical (and for some, religious and spiritual) implications of changing the human body with technology? In many ways, these are not new questions. We've used technology to augment the physical form since the first caveman picked up a walking stick. But the key here will be to focus as much (or more) on the way we use these technologies as we do on inventing them."

Bernie Hogan, senior research fellow at Oxford Internet Institute, wrote, "Tech will make life better for individuals but not for societies. Life-saving drugs, genetic medicine, effective talk therapy, better recommender systems will all serve individuals in a satisfying way. I am concerned,

however, that these will create increased dependency and passivity. We already have trends toward better-behaved, less-experimental and less-sexually-active youth. The increased sense that one's entire life is marked from cradle to grave will create a safer and more productive life, but perhaps one that is a little less low-risk and constrained."

Kenneth Grady, futurist and founding author of The Algorithmic Society blog, responded, "Fifty years from now today's notions of privacy will feel as out of date as horse and buggy transportation feels to us. Our homes, transportation, appliances, communication devices and even our clothes will be constantly communicating as part of a digital network. We have enough pieces of this today that we can somewhat imagine what it will be like. Through our clothes, doctors can monitor in real time our vital signs, metabolic condition and markers relevant to specific diseases. Parents will have real-time information about young children. The difference in the future will be the constant sharing of information, data updates and responses of all these interconnected devices. The things we create will interact with us to protect us. Our notions of privacy and even liability will be redefined. Lowering the cost and increasing the effectiveness of health care will require sharing information about how our bodies are functioning. Those who opt out may have to accept palliative hospice care over active treatment. Not keeping track of children real-time may be considered a form of child neglect. Digital will do more than connect our things to each other – it will invade our bodies. Advances in prosthetics, replacement organs and implants will turn our bodies into digital devices. This will create a host of new issues, including defining 'human' and where the line exists between that human and the digital universe – if people are always connected, always on are humans now part of the internet?"

Martin Geddes, a consultant specializing in telecommunications strategies, said, "I am optimistic that we will find a new harmony with technology, having been in dissonance for a long time. This will not be due to newfound wisdom or virtue, but due to the collapse of longstanding cultures and structures that are psychopathic in nature, including today's central banking systems and mass-surveillance systems. The digital and nano/biotech renaissance is only just beginning, and it will in particular transform health care. Our 'satnav for live' will help us navigate all daily choices that impact well-being."

Danil Mikhailov, head of data and innovation for Wellcome Trust, responded, "My view is that the internet and related digital tech such as AI 50 years from now will have mostly positive effects, but only if we manage its development wisely. In health, the pervasiveness of powerful algorithms embedded in mobile tech doing things like monitoring our vitals and cross-referencing with our genetic information, will mean longer and healthier lives and the disappearance of many diseases. Similarly, AI embedded in devices or wearables can be applied to predict and ameliorate many mental health illnesses. However, there is potential for there to be huge inequalities in our societies in the ability of individuals to access such technologies, causing both social disruption

and new causes for mental health diseases, such as depression and anxiety. On balance, I am an optimist about the ability of human beings to adjust and develop new ethical norms for dealing with such issues."

Dan Robitzski, a reporter covering science and technology for Futurism.com, commented, "The powers that be are not the powers that should be. Surveillance technology, especially that powered by AI algorithms, is becoming more powerful and all-present than ever before. But to look at that and say that technology won't help people is absurd. Medical technology, technology to help people with disabilities, technology that will increase our comfort and abilities as humans will continue to appear and develop."

Emanuele Torti, a research professor in the computer science department at the University of Pavia, Italy, responded, "The digital revolution will bring benefits in particular for health, providing personalized monitoring through Internet of Things and wearable devices. The AI will analyze those data in order to provide personalized medicine solutions."

João Pedro Taveira, embedded systems researcher and smart grids architect for INOV INESC Inovação, Portugal, wrote, "The most noticeable change for better in the next 50 years will be in health and average life expectancy. At this pace, and, taking into account the developments in digital technologies, I hope that several discoveries will reduce the risk of death, such as cancer or even death by road accident. New drugs could be developed, increasing the active work age and possibility maintaining the sustainability of countries' social health care and retirement funds."

José Estabil, director of entrepreneurship and innovation at MIT's Skoltech Initiative, commented, "AI, like the electric engine, will affect society in ways that are not linearly forecastable. (For example, the unification of villages through electric engines in subways has created what we know as Paris, London, Moscow and Manhattan). Another area AI can have impact is in creating the framework within genomics, epigenomics and metabolomics can be used to keep people healthy and to intervene when we start to deviate from health. Indeed, with AI we may be able to hack the brain and other secreting cells so that we can auto-generate lifesaving medicines, block unwanted biological processes (e.g., cancer), and coupled to understanding the brain, be able to hack at neurological disorders."

Jay Sanders, president and CEO of the Global Telemedicine Group, responded, "Haptics will afford the ability to touch/feel at a distance so that in the medical space a physician at one location will literally be able to examine a patient at a distance."

A director of marketing for a major technology platform company commented, "I was an early user of ARPANET at Carnegie Mellon University, and even then we were able to utilize

internet technology to solve human health problems to make citizens' lives better and improve their access to care and services to improve their health outcomes. The benefits of the internet in the health care industry have continued to improve access to care and services, particularly for elderly, disabled or rural citizens. Digital tools will continue to be integrated into daily life to help the most vulnerable and isolated who need services, care and support. With laws supporting these groups, benefits in these areas will continue and expand to include behavioral health and resources for this group and for others. In the area of behavioral health in particular, digital tools will provide far-reaching benefits to citizens who need services but do not access them directly in person. Access to behavioral health will increase significantly in the next 50 years as a result of more enhanced and widely available digital tools made available to practitioners for delivering care to vulnerable populations, and by minimizing the stigma of accessing this type of care in person. It is a more affordable, personalized and continuous way of providing this type of care that is also more likely to attain adherence."

The cyborg generation: Humans will partner more directly with technology

Many experts foresaw a future where the integration of technology and the human body would lead to a hybridization of humanity and technology.

Barry Chudakov, founder and principal of Sertain Research and author of "Metalifestream," commented, "In 50 years the internet will not be a place to access through a device; it will be the all-surrounding ether of actions and intentions as machine intelligence and learning merge with human intelligence. This will be a natural evolution of adopting the logic of our tools and adjusting our lives accordingly. Pathways to digital life will be neural pathways inside our bodies and brains. We will eat our technology. What is now external mediated through devices will become neural, mediated through neural triggers along neural pathways. Having gone (and living) inside us, the merger with our tools and devices will continue to accelerate due to advances in machine learning. Human identity will morph into an open question, an ongoing discussion."

Sam Lehman-Wilzig, associate professor and former chair of the School of Communication, Bar-Ilan University, Israel, wrote, "Given the huge (and completely unpredicted) changes of the 'internet' over the past 50 years, this question demands out-of-the-box thinking, which I will do here. Literally. In my estimation, within the next 50 years the internet will mainly become the platform for brain-to-brain communication, i.e., no keyboard, no voice, no screen, no text or pictures – merely 'neuronic' communication (thought transmission) at the speed of light, with internet speeds reaching terabytes per second, if not more than that. This also means that the main 'content' will be various forms of full-experience VR, fed directly to our brains by professional content providers – and perhaps (a bit science-fictiony at this stage) from our brains

to other brains as well. The consequences of such a 'hive mind' communication are difficult (if not impossible) to predict, but certainly it will constitute a radical break with past human society."

Joaquin Vanschoren, assistant professor of machine learning at Eindhoven University of Technology, Netherlands, responded, "We will be able to interact with each other and the world's information more directly, without going through web interfaces, maybe using a brain-internet interface. A lot more content will be generated automatically, by AI systems that help us fill in the holes in our knowledge and make it more easily accessible."

Frank Kaufmann, president of Filial Projects and founder and director of the Values in Knowledge Foundation, said, "Virtually nothing from today's internet will be recognizable 50 years from now. Connectivity will become ever more ethereal and divorced from devices. Speeds will have exceeded what can any longer be sensed by the human organism. Storage will seem limitless, as it will exceed all possible need. Most connectivity will be integrated into the biological organism…. Tech will enable creative people to create more. It will enable good people to do more good. It will enable lazy people to be more lazy. It will enable bad people to do more bad. It will enable family and social people to be closer and more loving. It will enable lonely and isolated people to become more isolated. It will enable radical advances in all things people do – sports, arts, medicine, science, literature, nature exploration, etc."

Karen Oates, director of workforce development for La Casea de Esperanza, commented, "At the rate at which technology is evolving, the internet as we currently know it and interact with it will have morphed into something very different. I can see people allowing implants in their bodies so they can connect to whatever the internet becomes – leveraging it as an auxiliary brain. This also, however, opens the door for manipulation and potential control of people. Like anything, technology can be used for good or evil. Much will be dependent on to what extent an individual is willing to sacrifice independence for comfort, security, etc."

Several other respondents voiced concerns about this future. **A law professor based at a U.S. university** said, "The book 'Re-Engineering Humanity' provides a reasonable description of the slippery, sloped path we're on and where we seem likely to be heading. The authors' big concern is that humans will outsource so much of what matters about being human to supposedly smart technical systems that the humans will be little more than satiated automatons."

David J. Krieger, co-director of the Institute for Communication & Leadership in Lucerne, Switzerland, wrote, "Everything will be 'personalized' but not individualized. The European Western paradigm of the free and autonomous individual will no longer be a major cultural force. Network collectivism will be the form in which human existence, now no longer 'humanist' will play itself out. There will be no other life than digital life and no one will really have the

opportunity to live offline. And if so, then there will probably be a three-class society consisting of the cyborgs, the hybrids and the naturals. This will of course generate new forms of social inequality and conflict."

Despite the likely drawbacks many respondents see the hybrid future as a strong possibility.

Mike Meyer, a futurist and administrator at Honolulu Community College, commented, "The world in 50 years is likely to be very difficult to imagine or understand in today's language. The options available will be contingent on many layers of both technology and human adaption that will occur over the next 50 years. This will be true as the steady acceleration of the rate of change continues based loosely on Moore's Law leading to true quantum computing. Genetic engineering combined with nano components that may also be bioelectronic in nature will allow planetary network communication with implants or, perhaps, full neural lace. The primary distinction will be between those people with full communication plus memory and sensor augmentation versus those who choose not to use artificial components in their bodies. Everyone will use a planetwide network for all communication and process activity whether through augmentation or very small headbands or other options that are not implanted."

Ray Schroeder, an associate vice chancellor at the University of Illinois, Springfield, wrote, "Connected technologies and applications will become much more seamlessly integrated into people's lives. Technologies are emerging, such as MIT's AlterEgo, that point to practical telepathy in which human thought will directly connect with supercomputers – and through those computers with other people. This kind of thought-based communication will become ubiquitous through always-on, omnipresent networks. Personal devices will fade away as direct connectivity becomes ubiquitous. These advances will enable instant virtual 'learning' of new ideas and the whole range of literature. One will be able to 'recall' a novel or a treatise as if one had studied it for years. Such will be the state of augmented memory. There will be attempts to apply new rules/laws, but technological capability will most often trump artificial restrictions. This will further empower people, by the power of their purchases and choice-to-use to set standards of acceptability and preference."

David Klann, consultant and software developer at Broadcast Tool & Die, responded, "Further integration of humans and machines is inevitable. More devices will be implanted in us, and more of our minds will be 'implanted' in devices. The inevitable 'Singularity' will result in changes to humans and will increase the rate of our evolution toward hybrid 'machines.' I also believe that new and modified materials will become 'smart.' For instance, new materials will be 'self-aware' and will be able to communicate problems in order to avoid failure. Ultimately, these materials will become 'self-healing' and will be able to harness raw materials to manufacture replacement parts in situ. All these materials, and the things built with them will participate in the connected

world. We will see continued blurring of the line between 'real' and 'virtual' life." **Anonymous respondents** predicted:

- "Artificial general intelligence and quantum computing available in a future version of the cloud connected to individual brain augmentation could make us augmented geniuses, inventing our daily lives in a self-actualization economy as the conscious-technology civilization evolves."
- "There is a probability of technological singularity. So far all the trends lead to it; it is hard to imagine a future in which this does not happen."
- "Connective symbiosis – human-human, machine-human, human-machine – will continue to thicken."
- "Implants in humans that continuously connect them to the web will lead to a loss of privacy and the potential for thought control, decline in autonomy."

Everyone agrees that the world will be putting AI to work

The technology visionaries surveyed described a much different work environment from the current one. They say remote work arrangements are likely to be the rule, rather than the exception, and virtual assistants will handle many of the mundane and unpleasant tasks currently performed by humans.

Ed Lyell, longtime internet strategist and professor at Adams State University, wrote, "If we can change the governance of technology to focus on common good growth and not a division of winner/loser then we can see people having more control over their lives. Imagine that the tough, hard work, dangerous jobs are done by machines guided by computers and AI. We can see the prototype of these in how the U.S. is now fighting wars. The shooting is done by a drone guided by a smart guy/gal working a 9-to-5 job in an air-conditioned office in a nice town. Garbage could be picked up, sorted, recycled, all by robots with AI. Tedious surgery completed by robots and teaching via YouTube would leave the humans to the interesting and exciting cases, not the redoing of same lessons to yet more patients/students. Humans could live well on a 20-hour work week with many weeks of paid vacation. Having a job/career could become a positive, not just a necessity. With 24/7 learning and just-in-time capacity, people could change areas or careers many times with ease whenever they become bored. This positive outcome is possible if we collectively manage the creation and distribution of the tools and access to the use of new emerging tools."

Jim Spohrer, director of the Cognitive OpenTech Group at IBM Research-Almaden, commented, "Everyone will have hundreds of digital workers working for them. Our cognitive mediators will know us in some ways better than we know ourselves. Better episodic memories and large

numbers of digital workers will allow expanded entrepreneurship, lifelong learning and focus on transformation."

Kyle Rose, principal architect, Akamai Technologies, wrote, "As telepresence and VR become more than research projects or toys, the already small world will shrink further as remote collaboration becomes the norm, resulting in major social changes, among them allowing the recent concentration of expertise in major cities to relax and reducing the relevance of national borders. Furthermore, deep learning and AI-assisted technologies for software development and verification, combined with more abstract primitives for executing software in the cloud, will enable even those not trained as software engineers to precisely describe and solve complex problems. I strongly suspect there will be other, unpredictable disruptive social changes analogous to the freer movement of capital enabled by cryptocurrencies in the last decade."

David Schlangen, a professor of applied computational linguistics at Bielefeld University, Germany, said, "Physical presence will matter less, as high-bandwidth transmissions will make telepresence (in medicine, in the workplace, in in-person interactions) more viable."

Ken Goldberg, distinguished chair in engineering, director of AUTOLAB and CITRIS at the University of California, Berkeley, said, "I believe the question we're facing is not 'When will machines surpass human intelligence?' but instead 'How can humans work together with machines in new ways?' Rather than worrying about an impending Singularity, I propose the concept of Multiplicity: where diverse combinations of people and machines work together to solve problems and innovate. In analogy with the 1910 High School Movement that was spurred by advances in farm automation, I propose a 'Multiplicity Movement' to evolve the way we learn to emphasize the uniquely human skills that AI and robots cannot replicate: creativity, curiosity, imagination, empathy, human communication, diversity and innovation. AI systems can provide universal access to sophisticated adaptive testing and exercises to discover the unique strengths of each student and to help each student amplify his or her strengths. AI systems could support continuous learning for students of all ages and abilities. Rather than discouraging the human workers of the world with threats of an impending Singularity, let's focus on Multiplicity where advances in AI and robots can inspire us to think deeply about the kind of work we really want to do, how we can change the way we learn and how we might embrace diversity to create myriad new partnerships."

Kristin Jenkins, executive director of BioQUEST Curriculum Consortium, said, "Access to information is enormously powerful, and the internet has provided access to people in a way we have never before experienced. This means that people can learn new skills (how to patch your roof or make bread), assess situations and make informed decisions (learn about a political candidate's voting record, plan a trip), and teach themselves whatever they want to know from

knowledgeable sources. Information that was once accessed through print materials that were not available to everyone and often out of date is now much more readily available to many more people. Ensuring access is another huge issue with internet 2.0/AI. Access to these tools is not guaranteed even within the U.S. – presumably one of the best places in the world to be wired. In many cases, access to current technology in developing areas of the world allows populations to skip expensive intermediate steps and use tools in a way that improves their quality of life. Ensuring that people all over the world have access to tools that can improve their lives is an important social justice issue."

Rich Ling, a professor of media technology at Nanyang Technological University, Singapore, responded, "In the next 50 years there will be significant changes in the way that we work. The disruption of that will play through to the way people identify themselves and can also be turned into political movements. AI is on the point of eliminating a wide variety of jobs and professions (taxi driver, accountant, law clerk, etc.). At the same time a large portion of our identity often comes from an idealized sense of our work. Witness the notion of being a cowboy. This is a real job for a small number of people, but it is an identity for many. In the same way, there is an identity in being a truck driver, an insurance adjuster, etc. It often does not have the same panache as the idealized version of being a cowboy, but it's nonetheless an identity. If that is taken away from people it can, in the worst case, lead to populist political movements. I answered that the general trend will be positive, but I expect that it is not a simple path to better lives through the application of IT. There are many social and eventually political issues that will be played out."

Divina Frau-Meigs, professor of media sociology at Sorbonne Nouvelle University, France, and UNESCO chair for sustainable digital development, responded, "The most important trend to follow is the way game/play will become the new work. Convergence of virtual reality and immersive devices will modify the rules determining how we interact with each other and with knowledge and information in the future. These 'alternative' realities will enable more simulations of situations in real life and will be necessary in decision-making every step of our daily lives. We will need to be conscious of the distinction between game and play, to allow for leisure time away from rule-bound game-as-the-new-work. This will be particularly necessary for environmental issues to be solved creatively."

Estee Beck, assistant professor at the University of Texas and author of "A Theory of Persuasive Computer Algorithms for Rhetorical Code Studies," responded, "Society will shift toward educating the public on reading and writing code at an accelerated rate. Coding literacy will become part of K-12 curricula to prepare citizens for both STEM-related careers and consumeroriented DIY solutions of tech problems. On the latter, because of the mass coding literacy spread in primary and secondary schooling, the 'handyman' will evolve into a tech tinkerer or handyman 2.0. Already acquainted with basic and intermediate home maintenance of basic

lighting, plumbing and painting, the handyman 2.0 will fix code in home appliances, run software updates to modify and personalize processes in the home. The handyman 2.0 might run their own server and develop a self-contained smartphone and security system to protect against internet-related attacks. For those unable or uninterested in being a handyman 2.0, they can hire general and specialized contractors from a new industry of handymen 2.0. This industry – with public and private certifications – will employ hundreds of thousands of laborers and enjoy revenues in the billions."

Hume Winzar, associate professor and director of the business analytics undergraduate program at Macquarie University, Sydney, Australia, wrote, "Working and study at a distance will be normalized, so lifestyle options will be wider. We won't need to live/work/study in a major city to enjoy the best of what is available. Done right, it will expand opportunity for many, too."

Barrack Otieno, general manager at the Africa Top-Level Internet Domains Organization, wrote, "I expect technology to enhance the work environment. The internet will mostly be used to enhance communication, coordination and collaboration."

Benjamin Kuipers, a professor of computer science at the University of Michigan, wrote, "In the post-World War II era, many people believed that American society was essentially benevolent, providing opportunities for political, economic and social advancement for individuals and families over decades and generations. This was somewhat true for the majority, but dramatically untrue for many minorities. We may have the opportunity to provide this societal benevolence for everyone in our society. The technological, often digital, tools we are creating have the promise of greatly increasing the resources available in society. While it may be possible to automate some current jobs, people have an intrinsic need for meaningful work. If we can use these new resources to support them, many jobs can be created to provide meaningful work for many people, and to improve the environment for everyone in society. Some examples of such jobs are child and elder care, and creation and maintenance of green spaces ranging from urban parks to rural farms to wilderness environments and many others. A national service requirement for young people gets certain kinds of work done, but also provides training in practical skills and practical responsibility, and also exposes individuals to the diversity of our society. Technological change produces resources that allow new things to be done and reduces certain constraints on what can be done. But we need to learn which goals we should pursue."

Lane Jennings, a recent retiree who served as managing editor for the World Future Review from 2009 to 2015, wrote, "Entire classes of humans (drivers, construction workers, editors, medical technicians, etc.) are likely to be replaced by AI systems within the next 50 years. Whether individual members of such groups feel their lives have been improved or made worse will vary depending on many factors. Suffice it to say that public support of some kind to give displaced

workers the means to live in relative security and comfort is essential. Moreover, this support must be provided in a way that preserves self-respect and promotes optimism and ambition. A world of former workers who perceive themselves as having been prematurely retired while machines provide the goods and services they once supplied seems to me highly unstable. To be happy, or at least contented, people need a purpose beyond simply amusing themselves and passing time pleasantly. One of the major functions of the internet in 2069 may be to facilitate contact between people with skills who want to work and jobs that still need doing in spite of high-tech robots and ubiquitous AI."

Mark Crowley, an assistant professor expert in machine learning and core member of the Institute for Complexity and Innovation at the University of Waterloo, Ontario, Canada, wrote, "Technology affects people asymmetrically. Diseases will be cured with machine learning, profits will rise with automation and artists, engineers and scientists will be able to do more with less time and resources than ever before. However, many people will lose the only jobs they've ever known, and many others will feel alienated and left behind. Will society take steps to adapt its social standards? Will education adapt to prepare each generation for the reality ahead rather than focusing on the past? Will we allow people to live, with dignity, their own life, even if rapid technological changes leave them without a job that we would traditionally call 'useful' or productive? That depends on politics."

Josh Calder, a partner at the Foresight Alliance, commented, "Changes will be for the better if the wealth generated by automation is spread equitably, and this will likely require significant changes to economic systems. If wealth concentration is accelerated by automation, the average person could be worse off."

In 2069 the 'new normal' will be …

If the future is to change as dramatically and rapidly as many of the survey respondents believe, the world will see seismic shifts in norms and in what might be considered "normal" life.

Cliff Lynch, director of the Coalition for Networked Information, responded, "Over the next 20 to 30 years I expect to see enormous renegotiation of the social, cultural and political norms involving the digital environment."

Alistair Nolan a senior policy analyst in the OECD Directorate for Science, Technology and Innovation, wrote, "I speculate that individuals' interaction with digital technologies will become much more pervasive and intimate than it is already. Digital technology will be used to counter some of the stresses created by economic development and a digital culture. Digital avatars, for example, might provide intelligent company for the old and lonely, coaching those subject to

psychological disorders, encouraging and guiding the sedentary to adopt healthier lifestyles, and so on. But changes and societal stresses brought by digital technologies may require a fundamental overhaul of the social contract. A new digital social contract will likely be needed, the specifics of which we cannot be sure now, but the contours of which we see suggested today in proposals ranging from universal basic income to institutionally mandated time free from digital distraction. The hope is that political processes allow our social arrangements to adjust at a pace commensurate with broader technological change, and that dysfunction in political processes is not aggravated by digital technologies. It has been commented that when humankind attempts to take astronauts to Mars the primary challenge will not be technological. Instead, it will be social: namely, the ability of unrelated individuals to live in close confinement for long periods of time. At the level of entire polities, in a similar way, our primary challenge may be living together in civil ways, attending to the full range of human needs, while the technology brings opportunities to carry us forward, or carry us off course."

Greg Shannon, chief scientist for the CERT Division at Carnegie Mellon University's Software Engineering Institute, said, "Pervasive/complete/competing memories – capture/network/storage tech will allow complete digital records of each life, with fast recall for discussion, disagreements and manipulation. What will it mean to not have to remember, that you can recall the video with higher fidelity than one could ever remember? This will disrupt social norms. Communities specified by degrees of anonymity and other variable social norms. With pervasive sensing/monitoring, communities can define and enforce norms. From everyone wears green on April 20 to verbal violence is OK (or not) to which laws are well-defined and must be followed 100% of the time (what does it mean to really stop at a stop sign?). AI and IT (information technology) can define, enforce and update norms at scale and quickly…. No one is perfect and social norms in communities will vary with AI/IT helping ensure/permit the varied norms. Nonlocality of communities. We already see this today with the various groups – mailing lists, conference calls, website, hashtags, etc. – that define communities that can be very tight/loose, small/large local/global. This might impact happiness; if everyone physically around you is a stranger (not in one of your communities), what will that mean for the physiological aspects of happiness – touch, smell, tastes, complex sounds and sights? At a technical level, the RF (radio frequency) signature of [an] individual will become increasingly important as the wired last mile disappears. Social norms will include RF – peaceful or aggressive/harmful. And you won't be able to hide it [any] more than you can hide walking down the street."

Betsy Williams, a researcher at the Center for Digital Society and Data Studies at the University of Arizona, wrote, "Free internet-connected devices will be available to the poor in exchange for carrying around a sensor that records traffic speed, environmental quality, detailed usage logs, and video and audio recordings (depending on state law). There will be secure vote-by-internet capabilities, through credit card or passport verification, with other secure kiosks available at

public facilities (police stations, libraries, fire stations and post offices, should those continue to exist in their current form). There will be a movement online to require real-name verification to comment on more reputable sites; however, this will skew participation tremendously toward men, and the requirements will be reversed after a woman is assaulted or killed based on what she typed in a public-interest discussion."

Pamela Rutledge, director of the Media Psychology Center, responded, "Starting with Generation Z and going forward, internet and 24/7 real-time connectivity will no longer be viewed as a 'thing' independent from daily life, but integral, like electricity. This has profound psychological implications about what people assume as normal and establishes baseline expectations for access, response times and personalization of functions and information. Contrary to many concerns, as technology becomes more sophisticated, it will ultimately support the primary human drives of social connectedness and agency. As we have seen with social media, first adoption is noncritical – it is a shiny penny for exploration. Then people start making judgments about the value-add based on their own goals and technology companies adapt by designing for more value to the user – we see that now in privacy settings and the concerns about information quality…. Technology is going to change whether we like it or not – expecting it to be worse for individuals means that we look for what's wrong. Expecting it to be better means we look for the strengths and what works and work toward that goal. Technology gives individuals more control – a fundamental human need and a prerequisite to participatory citizenship and collective agency. The danger is that we are so distracted by technology that we forget that digital life is an extension of the offline world and demands the same critical, moral and ethical thinking."

Geoff Livingston, author and futurist, commented, "Technology will become a seamless experience for most people. Only the very poor who cannot afford technology and the very rich who can choose to separate themselves from it will be free from connectedness. When I consider the current AI conversation, I often think the real evolution of sentient beings will be a hybrid connectedness between human and machine. Our very existence and day-to-day experience will be through an augmented experience that features faster thinking and more ethereal pleasures. This brings a question of what is human? Since most of us will be living in a machine-enhanced world, the perspective of human reality will always be in doubt. Most will simply move through their existence without a thought, able to change and alter it with new software packages and algorithms, accepting their reality as the new normal. Indeed, perception will become reality. There will be those who decry the movement forward and wish for yesteryear's unplugged mind. The counter movement against the internet of 2070 will be significant, and yet much like today's Luddite, it will find itself in the deep minority. For though the cultural implications will be significant, the internet of 2070 offers the world a much more prosperous and easier life. Most will choose comfort over independence from devices."

Meryl Alper, an assistant professor of communication at Northeastern University and a faculty associate at the Berkman Klein Center for Internet and Society, wrote, "Parents will be inundated by non-intuitive, AI-sourced information about their children (e.g., their moods, their behaviors) through the data collected about them in their everyday lives. Parents will face a choice about knowing too much about every single aspect of what their child does and says (be it with them or without them) or not knowing all the details – while being aware that someone else (teachers, doctors, law enforcement) is compiling this information for later determinations of some kind about their child. Parents will ultimately be encouraged to automate this data-intensive parenting, but this itself will create more work for parents (and thus more work for parents to outsource)."

Uta Russmann, professor in the Department of Communication at FHWien der WKW University of Applied Sciences for Management & Communication, warned, "In 50 years every aspect of our life will be connected, organized and hence, partly controlled, as technology platform and applications businesses will take this opportunity. A few global players will dominate the business; smaller companies (startups) will mostly have a chance in the development sector. Many institutions, such as libraries, will disappear – there might be one or two libraries that function as museums to show how it used to be. People who experienced today's world will definitely value the benefits and amenities they have through technology (human-machine/AI collaboration). If technology becomes part of every aspect of our lives we will have to give up some power and control. People thinking in today's terms will lose a certain amount of freedom, independency and control over their lives. People born after 2030 will probably just think these technologies produced changes that are mostly for the better. It has always been like this – people have always thought/said 'in the old days everything was better.'"

Danny Gillane, a netizen from Lafayette, Louisiana, commented, "The content owners will become the platform companies (Disney, Time Warner, etc.), and the platform companies will become the content owners (Comcast, Netflix, etc.). In the U.S., we will give up more privacy to gain more convenience. We will have to choose between paying with our wallets or paying with our personal information in order to keep up with the Joneses. Collaboration and communication will become less personal as more of it will be done through virtual reality and through our devices. The promise of worldwide connection will lessen as Europe places restrictions on tech companies to protect its citizens' rights, but the U.S. will pass laws to protect shareholders even at the expense of its citizens' rights. Unless the focus of technology innovation moves away from consumer entertainment and communication products (such as social networks) and more toward medical and scientific advances, we will see fewer people truly benefiting from the internet. The money that fuels America's politics already fuels its legislative efforts, or lack of, with regard to technology. So, I actually don't think we'll see any actual change, unless one considers for-profit companies having an even larger presence in more parts of our lives more often and in more ways."

Justin Reich, executive director of MIT Teaching Systems Lab and research scientist in the MIT Office of Digital Learning, responded, "The trends toward centralization and monopolization will persist. The free, open internet that represented a set of decentralized connections between idiosyncratic actors will be recognized as an aberration in the history of the internet. Today's internet giants will probably be the internet giants of 50 years from now. In recent years, they've made substantial progress in curtailing innovation through acquisitions and copying. As the industry matures, they will add regulatory capture to their skill sets. For many people around the world, the internet will be a set of narrow portals where they exchange their data for a curtailed set of communication, information and consumer services."

Michael R. Nelson, a technology policy expert for a leading network services provider who worked as a technology policy aide in the Clinton administration, commented, "We will see more change and disruption in the next 10 years than we have seen in the last 20. If governments and incumbents allow it, we could see twice as much. All we know about 2069 is that data storage, network capacity and tools to turn data into knowledge will be basically unlimited and cost almost nothing. But, we also know that the wisdom needed to use the power of technology will not be available to everyone. And we also know that political forces will try to create scarcity and favor some groups over others. Let us hope that the engineers innovate so fast that consumers have the tools and choices they need to overcome such constraints."

Guy Levi, chief innovation officer for the Center for Educational Technology, based in Israel, wrote, "Digital tools will be part of our body inside and remotely, and will assist us in decision-making constantly, so it will become second nature. Nonetheless, physical feelings will still be exclusively 'physical,' i.e., there will be a significant difference between the 'sensor-based feelings' and real body feelings, so human beings will still have some advantages over technology. This, I believe, will last forever. Considering this, physical encounters among people will become more and more important and thus relationships, especially between couples, will prosper. It will be the return of LOVE."

No need to give it orders – your digital assistant already knows what you want

Many of these experts expect that – despite some people's worries over privacy issues – digital experiences will be far more personalized in 2069. One likely trend: Instead of having to directly communicate requests to a device, AI-enabled, database-fed digital technologies will anticipate individuals' needs and provide customized solutions.

Michael Wollowski, associate professor of computer science and software engineering at RoseHulman Institute of Technology, expert in the Internet of Things, diagrammatic systems and artificial intelligence, wrote, "Much of our lives will be automated. Better yet, we will be in control

of the degree of automation. Technology will assume the role of a polite personal assistant who will seamlessly bow in and out. Technology based on learned patterns of behavior will arrange many things in our lives and suggest additional options."

Peter Reiner, professor and co-founder of the National Core for Neuroethics at the University of British Columbia, Canada, commented, "The internet will remain a conduit for information about us as well as a tool for us to access information about the world. Whilst many commentators rightly worry about the degree to which apps can know about us today, we are only at the early stages of corporate and governmental surveillance of our inner lives. In 50 years' time, apps will be remarkably more sophisticated in terms of their knowledge about us as agents – our wants and desires, our objectives and goals. Using that information, they will be able make decisions that align with our personal goals much better than they can do today, and as this happens they will become bona fide extensions of our minds – digital (or as seems likely, quantum-based) information-processing interfaces that are always available and seamlessly integrate with the human cognitive toolkit. These cognitive prostheses will be so much a part of our everyday lives that we will barely notice their existence. Our reliance upon them will be both a strength and a weakness. Our cognitive prowess will substantially expand, but we will feel diminished in their absence."

David Zubrow, associate director of empirical research at the Carnegie Mellon Software Engineering Institute, said, "Networked devices, data collection and information on demand will become even more ubiquitous. I would hope that better curation of information along with its provenance occurs. The trend of digital assistants that learn your preferences and habits from all the devices that you interact with will become integrated with each other and take on a persona. They may even act on your behalf with a degree of independence in the digital and physical worlds. As AI advances and becomes more independent and the internet becomes the world in which people live and work, laws for responsibility and accountability of the actions of AI will need to be made."

Daniel Siewiorek, a professor with the Human-Computer Interaction Institute at Carnegie Mellon University, predicted, "We will all have virtual coaches that learn and grow with us. They will be in communication with the virtual coaches of others, allowing us to learn from the experience of others. For example, my grandfather could teach me how to swing a baseball bat through his virtual coach even though my grandfather passed away before I was born."

Gary Kreps, distinguished professor of communication and director of the Center for Health and Risk Communication at George Mason University, wrote, "Future computing systems will be fully integrated into everyday life, easy to access and use, and adaptable to meeting individual preferences and needs. These devices will serve as integrated personal assistants that can

intuitively provide users with relevant information and support. There will be no need for typing in requests, since systems will be voice- and perhaps even thought-activated. These systems will adapt to user communication styles and competencies, using familiar and easy to understand messages to users. These messages will be presented both verbally and visually, with the ability to incorporate vivid examples and relevant interesting stories for users. Information content will build upon user preferences, experiences and needs. These personal computing systems will learn about users and adapt to changing user needs, assisting users in accomplishing important tasks and making important decisions. These systems will also automatically network users to relevant personal and professional contacts to facilitate communication as desired by users. The systems will also help users control other forms of technology, such as transportation, communication, health care, educational, occupational, financial, recreational and commercial applications. Care must be taken to program these systems to be responsive to user preferences and needs, easy to use, adaptive to changing conditions and easy for users to control."

Mike Meyer, futurist and administrator at Honolulu Community College, commented, "It is becoming clear that, as human numbers increase to 10 billion and beyond in the next 50 years, diversity will be more and more valuable. The very nature of the technology that will become part of our bodies … [It] will shape the very nature of our communities and the natural result will be homogenization of the species. The nature of [the] planet will become predominantly urban with constant instantaneous communication. We are already well on the way to a planetary culture based on current metropolitan areas. This is a tremendous benefit allowing the move to AI-based management following universally defined and expanded rights. The desire will be for change and difference, innovation and originality to counter the growing sameness. This may, finally, eliminate the problem of irrational bigotry, racism and xenophobia. But that will lead to personal augmentation and, probably, genetic engineering to regain diversity under our individual control. A major challenge that I see is the management of virtual worlds for people with specific ideas or ideals who wish to and could live in the world as they want it to be. How will this be handled physically ('The Matrix' model) and morally? Living as master of a slave plantation may be desired by some. Should that be an option with no 'real' people involved? Overall the tremendous expansion of options will be good. But more questions will arise from this and answers may be difficult."

Ian Rumbles, a quality-assurance specialist at North Carolina State University, said, "Fifty years from now the internet will be available to us through us thinking, versus using a keyboard or speaking. The display of data will be visible only to the user and how that display is shown will be totally customized for that user. The ability to obtain answers to questions and look up information in a format that is defined by the user will greatly improve the lives of people."

More leisure time expected in 'real life' and virtual worlds

Could it be true that technology will finally create more free time? Some respondents in this study expect that the evolution of digital technologies will allow for more leisure activities and less "work." Some predict people may choose to live most of their lives in a virtual reality that lacks the messy authenticity of real life. They also predict that in the widening global media marketplace of the future individuals will have access to a wider range of entertainment options than ever before.

Dan Schultz, senior creative technologist at the Internet Archive, said, "The world is about to have a LOT more time on its hands, a culture-redefining level of newfound time. Governments will need to figure out how to ensure people are compensated for that time in ways that don't correlate to capitalistic value, and people are going to need creative outlets for their free time. We're going to need better mental health services; we're going to need to finally redefine the public education system to shift away from the 19th century factory model. It will either be a golden age for invention, leisure, entertainment and civic involvement, or it will be a dystopia of boredom and unemployment."

James Gannon, global head of e-compliance for emerging technology, cloud and cybersecurity at Novartis, responded, "In 50 years machine-to-machine communication will have reduced a lot of menial decision-making for the average person. Smart-home technology manages the basic functions of the household, negating the need for many manual labor roles such as cleaners and gardeners. Many services are now delivered remotely such as telehealth and digital therapeutics…. Technology and the internet have already dramatically increased the standard of living for billions of people; this trend will not cease."

Chao-Lin Liu, a professor at National Chengchi University, Taiwan, commented, "If we can handle the income and work problems, lives will be easier for most due to automation."

Paola Perez, vice president of the Internet Society chapter in Venezuela and chair of the LACNIC Public Policy Forum, responded, "Technology will make everything in our lives. We won't drive, we won't cook. Apps are going to be adapted to all our needs. From the moment we wake up we are going to have technology that cooks for us, drives for us, works for us and suggests ideas for our work. Problems are going to be solved. But all our data is going to be known by everybody, so we won't have private lives."

Alex Smith, partner relationship manager at Monster Worldwide, said, "Everything will be centered around saving us time – giving us back more time in our days."

A professor of communications said, "Simple, mundane tasks will be taken care of by AI, allowing more time for creative thinking, arts, music and literature."

David Wells, the chief financial officer at Netflix at the time of this canvassing, has an idea for how to fill all of that free time. He predicted, "Continued global connectedness with our entertainment, music and news will mean global popularity of some media with a backdrop of local flavor that may be regional and/or hyper local. 3D visual (virtual) rendering will evolve and become integrated into user interfaces, discovery interfaces along with AI assistants, and will heavily define learning and entertainment."

Gabor Melli, senior director of engineering for AI and machine learning for Sony PlayStation, responded, "By 2070, most people will willingly spend most of their lives in an augmented virtual reality. The internet and digital life will be extraordinary and partially extraplanetary. Innovations that will dramatically amplify this trajectory are unsupervised machine learning, fusion power and the wildcard of quantum computing."

Valarie Bell, a computational social scientist at the University of North Texas, commented, "While the gadgets and tools we may have in the future may result in more conveniences, like when ovens turned into microwaves, we find with technology that we trade quality and uniqueness for convenience and uniformity. What tastes better and provides a better experience? The homemade chocolate cake Grandma made from scratch with attention to great ingredients and to baking the cake until it's perfectly moist OR the microwaved chocolate-cake-for-one? The microwave cake takes less than 10 minutes and you simply add water, but Grandma's cake is not over-processed, and you taste the real butter, real vanilla, real chocolate instead of powdered butter flavoring and powdered chocolate substitute. Technology will bring us things faster, perhaps even cheaper, but not necessarily better."

Michel Grossetti, a sociologist expert in systems and director of research at CNRS, the French national science research center, wrote, "The boundaries between private life and work or public life will continue to blur."

Social connections, community and collaboration will be improved

Some experts expect that digital advances will lead to better communication among disparate groups, resulting in stronger interpersonal relationships and positive community development. A number of respondents said that physical barriers to communication and community building will mostly disappear over the next half century. They are hopeful that greater connectivity will lead to better collaboration in response to major world problems, more equitable distributions of wealth and power and easier access to information and resources.

Tomas Ohlin, longtime professor at Linköping and Stockholm universities in Sweden, predicted, "AI will exist everywhere. The internet will, after a few decades, be replaced by a more value-added surface on top of our present system. Its governing will be truly decentralized, with participation

from many. Cultural differences will exist on this surface, with borders that will differ from the present. However, there will not be as many borders as today; this new information society is a society with flexible borders. Human beings are friendly, and the world we create reflects this. Communication and contact between everybody is a fundamental and positive resource that will lead to fewer conflicts."

Bryan Alexander, futurist and president of Bryan Anderson Consulting, responded, "I'm convinced we'll see individuals learn how to use technologies more effectively, and that collectively we'll learn how to reduce harm."

Charles Zheng, a researcher into machine learning and AI with the U.S. National Institute of Mental Health, commented, "Life will not qualitatively change much for people in the middle and upper classes of society. The biggest impact will be to the lower classes, and will mostly be positive. The increase in information gathering in all levels of society will also improve the efficiency of social welfare programs. Access to information becomes democratized as cities start offering free, basic Wi-Fi and the government hosts AI educational programs which can teach young people how to find jobs and access public resources. The increase in networking also makes … social nonprofits more effective at helping the disadvantaged. Government accountability is also improved now that people at all levels of society can leave reviews about government services online."

Craig Mathias, principal at Farpoint Group, an advisory firm specializing in wireless networking and mobile computing, commented, "Civilization itself centers on and thus depends upon communication of all forms. The more we communicate, the better the opportunities for peace and prosperity on a global basis. It would be difficult to imagine communications without the internet, now and especially in the future."

Gene Crick, director of the Metropolitan Austin Interactive Network and longtime U.S. community telecommunications expert, wrote, "Genuine universal technology access has become a vital issue for every community. AI/IT can make powerful tools, resources and opportunities available to anyone interested. To help rhetoric become reality, we could adopt and insist on a few fundamental principles, including standards for openness and accountability. How? Just a notion but perhaps a modernized version of the National Science Foundation internet administration transfer two decades ago. Though the outcome was far from pretty, those who participated felt we got the job done. Today's improved communications tools could make possible a much simpler, more widespread 'grassroots' discussion and decision process."

Jean-Daniel Fekete, researcher in information visualization, visual analytics and humancomputer interaction at INRIA, France, said, "The connected world will become even more

integrated in our life and appliances, as a virtual extension of our physical world. Physical location [will] become less important, blurring the notion of workplace, home, vacation, traveling. In that world, humans will have easy access to mostly all intellectual resources, but companies will be fighting for human attention. Advertising is already too efficient, diverting attention already. Mitigating these threats will become essential to maintain a healthy humanity."

Liz Rykert, president at Meta Strategies, a consultancy that works with technology and complex organizational change, responded, "We will see more and more integration of tools that support accountability. An early example of this is the use of body cams by police. The internet will let us both monitor and share data and images about what is happening, whether it is a devastating impact of climate change or an eventful incident of racism. Continued access to tools of accountability and access to knowledge and collaborative opportunities will support people to be both bold and collaborative as they seek new solutions. The internet will be the base to support these efforts as well as the platform that will continue to serve as the means for how we will work together to respond to problems either urgent (like a flood or fire) or longer-term like solving problems like affordable housing."

Matt Belge, founder and president of Vision & Logic, said, "Humanity has always strived to be connected to other humans, and writing, publishing, art and education were all efforts to serve this desire. This desire is so deeply seated, this desire for connection, that it will drive everything we do. Privacy will become less of a concern and transparency will become more of the norm in the next 50 years. Therefore, I expect technology to enable deeper and more personal connections with fewer secrets and greater openness. Specifically, AI will help people with like interests work together, form deeper relationships and collaborate on advancing our entire species. I believe humans are always striving for more and more connection with other humans and technology is evolving in ways to facilitated this."

Sam Ladner, a former UX researcher for Amazon and Microsoft, now an adjunct professor at Ontario College of Art & Design, wrote, "We will continue to see a melding of digital and analog 'selves,' in which humans will now consider their digital experiences less and less divorced from their face-to-face experiences. Face-to-face social connections will become ever more precious, and ever more elusive. Having an 'in real life' relationship will be a commodity to be exploited and a challenge to keep. Physical experiences will increasingly be infused with digital 'backchannel' experiences, such as an ongoing digital conversation either in text, images or VR, while the physical event carries on. Likewise, IRL (in real-life) events will become even more exclusive, expensive and a source of cultural capital. Isolated people will fail to see their isolation before it reaches a desperate point, because collectively, we will fail to see physical connections as a key ingredient to ward off loneliness. Loneliness will take on a new meaning; digital friends will assist some isolated people, but loneliness will focus more on lack of human touch, and face-to-face eye

contact. New medical disorders will emerge, based on this social withdrawal, and given the aging demographic, a public policy crisis will overwhelm nation-states' budgets and capabilities. Lonely, aging, physically infirm people may find relief in online forums of all sorts, but we will be surprised to learn what a total absence of IRL interaction will yield."

Peggy Lahammer, director of health/life sciences at Robins Kaplan LLP and legal market analyst, commented, "Historically access to natural resources, with limited intelligence on how to best use those resources, provided the means to survive and prosper. As we continue to become more specialized in our expertise and less skilled in many tasks required to survive, we are more dependent on others with specialized talents. I believe the internet and a connected world have fueled this transformation and will continue to do so in the next 50 years. The internet will continue to connect people around the globe and cause instability in areas where people have limited resources, information or specialized skills necessary to thrive."

Bert Huang, an assistant professor in the Department of Computer Science at Virginia Tech focused on machine learning, wrote, "I believe the internet can meet the promise of helping people connect to all of humanity. The main concern I see with the internet is that it plays counter to human intuitions about scale. When humans see thousands of like-minded individuals on the internet, it is too easy to believe that those thousands of people represent all of humanity. One promise of the internet is that it would allow people to interact with, and learn from, individuals with widely different backgrounds, unifying the human species in way that was previously impossible. Unfortunately, the more recent effect has apparently been that people are further entrenched in their own narrow views because they are surrounded on the internet with inconceivably large numbers of people sharing their own views. These large numbers make it difficult for people to fathom that other valid views exist. I believe technology can and will help alleviate this problem."

A technical information science professional commented, "The daily living 'operations' will change drastically from today – how we work, how we take care of family, how we 'commute' from place to place, how we entertain and so on. However, the fundamental of living, creating and maintaining meaningful relationships with others will be more dominant focus of our lives, and those concerns and efforts will not change."

Several of the expert respondents who said they believe humanity will be better off in the future thanks to digital life said that in 50 years individuals will have greater autonomy and more control over their personal data.

Eileen Donahoe, executive director of the Global Digital Policy Incubator at Stanford University, commented, "I envision a dramatic change in terms of how we think about people's ownership and

control of their own data. People's data will be seen as a valuable commodity and platforms will arise to facilitate data sovereignty for individuals. If we move toward development and deployment of platforms and systems that allow individuals autonomy to choose when and where they exchange their data for goods and services, this will constitute an important positive step toward wider distribution of the benefits of a data-driven society."

Greg Lloyd, president and co-founder at Traction Software, responded, "The next 50 years will see performance of hardware, storage and bandwidth increase and cost decrease at a rate no less than the past 50 years. This means that the resources available to any person – at the cost of a current smartphone and network subscription – will be close to the resources supporting a Google regional center. This will turn the advertising supported and privacy invasive economic model of the current internet on its head, making it possible for anyone to afford dedicated, private and secure resources to support a Prospero and Ariel-like world of certified and secure services. That people agreed to grant access to their most private resources and actions to platform companies in order to support use of subsidized internet services will become as oddly amusing as the fact that people once earned their living as flagpole sitters. Your smartphone and its personal AI services will be exactly that: your property, which you pay for and use with confidence. When you use certified agents or services, you'll have choices ranging from free (routine commerce, public library or government services) to fabulously expensive (the best legal minds, most famous pop stars, bespoke design and manufacturing of any artifacts, membership in the most exclusive 'places'). In all cases your personal smartphone (or whatever it turns into) will help you negotiate enforceable contracts for these services, monitor performance and provide evidence any case of dispute. Think Apple with a smart lawyer, accountant, friend and adviser in your smartphone, not Facebook becoming Silicon Valley's version of Terry Gilliam's 'Brazil.'"

James Scofield O'Rourke, a professor of management at the University of Notre Dame specializing in reputation management, commented, "I foresee two large applications of digital connections such as the internet over the next half century. First, I see access to information, processes and expertise that would either be delayed or inaccessible today. Second, I see a much larger degree of autonomy for the individual. This could mean everything from driverless trucks, automobiles and other vehicles to individual control over our immediate environment, our assets and possessions, and our ability to choose. In exchange, of course, the notion of privacy will virtually disappear."

R "Ray" Wang, founder and principal analyst at Silicon Valley-based Constellation Research, said, "The new internet can also be a place where we decentralize human rights, enabling an individual to protect their data privacy and stay free. Keep in mind privacy is not dead. It's up to us as a society to enforce these human rights."

Susan Aaronson, a research professor of international affairs and cross-disciplinary fellow at George Washington University, responded, "I admit to being a techno optimist. I believe that true entrepreneurs 'see' areas/functions that need improvements and will utilize technologies in ways that make it easier for, as an example, the blind to see."

5. Leading concerns about the future of digital life

The comments in the following section are a sharp contrast to the utopian visions of equity and advancement described above. Whereas some see the future of the internet as a great equalizer, others warn that technology can just as easily be used for control and exploitation.

Inequality on the rise: The growing divide between haves and have-nots

The majority of respondents to this study are in agreement that digital life is likely to improve the lives of people at the top of the socioeconomic ladder over the next few decades. A large share of those who predicted that internet use will produce change for the worse for most individuals over the next 50 years expressed concerns that an extension of current trends will lead to a widening economic divide that leaves the majority in the dust of the privileged class.

Johanna Drucker, professor of digital humanities in the department of information studies at the University of California, Los Angeles, said, "The question ignores the growing and disastrous division between poor, disenfranchised populations and wealthy, privileged ones. There may be huge improvements in *some* people's lives and negative impacts for many, many more – pollution, toxins from waste generated by electronic media, deregulation of labor conditions for workers in the high-tech industries, deterioration of support systems and social infrastructure and so on."

Michael Kleeman, a senior fellow at the University of California, San Diego, and board member at the Institute for the Future, wrote, "Because of the economic disparity the new technologies will be used with those with access to more resources, financial and technical. The digital divide will not be one of access but of security, privacy and autonomy."

Jillian C. York, director of international freedom of expression for the Electronic Frontier Foundation, commented, "I don't believe that technology will be a net negative; rather, I worry and suspect that it will make life better for some of us but worse for others. Much of the technology coming out of Silicon Valley aims to serve elites, when we should be aiming toward equality for all."

Zoetanya Sujon, a senior lecturer specializing in digital culture at University of Arts London, commented, "In my view, and drawing from the growth of global big tech companies and decreased pluralization of global platforms, I believe that in 50 years, the economic and cultural

divides between rich and poor, developed and developing nations, technologically advanced and disadvantaged will continue to grow. These divides are serious and already take place within urban centers, between developing and developed nations, and between rural and urban areas, to name only a few sites of division. Thus, for those with capital, including access to new technologies and the literacies that come with them, life will likely involve wearable and ubiquitous computing based on internet and platformed communication…. These kinds of tools will likely be available only to those with the economic and cultural capital to access them."

John Laudun, a respondent who provided no identifying details, commented, "The next 50 years is going to be great for a percentage of humans smaller than the percentage of humans for whom things will probably get worse. We continue to forget that 75% of the world's populations are effectively peasants, individuals (living in families, groups, etc.) who engage in subsistence agriculture. Too often when we project into the future we imagine ourselves, people like us or the people we think we see. But there are hosts of groups that we do not see. How will technological advances, and their various implementations, help or hurt them? No one, for example, could have predicted the explosion in micro-transactions connecting villagers to one another and a wider world thanks to the cellphone."

Christopher Leslie, lecturer in media, science and technology studies at South China University of Technology, wrote, "There will be many opportunities for consumers and entrepreneurs in the internet of the future, but the technology will mostly enhance the businesses and countries that already are ahead. It seems likely that a different kind of networking technology, perhaps truly decentralized and certainly separated from telecommunications companies, will be developed to challenge the inequalities fostered by today's use of internet technology. The general trend in the technological society to this point has been that more people have received more benefits to their lives. This is in terms of any meaningful metric: health care, education, political participation, sense of self. This will continue into the next 50 years. However, the inequalities perpetrated by the modern use of digital technology will mean that not all people will benefit. The overall trend will be positive, but some ways of life and some categories of people will suffer a detriment that may be extreme."

John Willinsky, professor and director of the Public Knowledge Project at Stanford Graduate School of Education, explained why he selected the automated survey response that digital life will be mostly beneficial for most individuals' lives over the next few decades: "I say 'mostly for the better' as both praise and critique, because the 'mostly' speaks to the continuing inequities in the distribution of the 'better,' and – while 'mostly' suggests a majority of benefits – it will take a great deal of concern and effort to ensure that that those benefits are distributed with some lesser degree of inequality than previously to more people and, by the same token, more people need to participate in the processes behind that distribution."

Fernando Barrio, director of the law program at the Universidad Nacional de Rio Negro, Argentina, commented, "The ubiquitous-tech society will imply a better, more enjoyable life for those being part of it. Wearable technology, tech implants, AI-medicine, autonomous robot workers and companions and many other coming technologies will allow humans to reach new limits of what to do and expect. However, the question is, with an ever-increasing income concentration at global scale in almost every country, how many members of the society will be able to be part of the enjoyment of that ubiquitous, hyper-connected, AI-tech society?"

James Scofield O'Rourke, a professor of management at the University of Notre Dame, commented, "People will be 'mostly better off' in 50 years' time, largely because of our ability to apply things we already know, i.e., the decoding of the human genome, our understanding of the fragility of our planetary environment and more. The singular exception will be that group of people who have no assets, no education, no opportunity, and as a result, no hope. They will be reduced to dependence on the kindness of neighbors, strangers and the government."

Elizabeth Feinler, the original manager of the ARPANET Network Information Center and an Internet Hall of Fame member, said, "As the internet matures, I hope the big guys will remember the little guys. As a pioneer, I remember when the Steve Jobs, Bill Gates, Jeff Bezos, Sergey Brins and countless other famous and successful entrepreneurs were working out of garages or dorm rooms, often penniless but with a lot of perseverance behind a great idea. Leave room for the next little guy – the one who comes up with a great pair of socks, or produces lovely artwork, or sells that gizmo you can't live without for $19.95, or develops a security system that works, or cures cancer or Alzheimer's – to hang their shingles on the internet too. True, one of them may challenge your greatness – it's the American way – but don't crowd them out. Just make your own service, product or idea better, and enjoy the challenge."

Michael Veale, co-author of "Fairness and Accountability Designs Needs for Algorithmic Support in High-Stakes Public Sector Decision-Making" and a technology policy researcher at University College London, responded, "Technological change will improve some of the lowest standards of living in the world today, but beyond a certain point (e.g., provision of basic needs), it is unclear who will benefit. It is likely that technological change will force countries to reconsider how they measure welfare, progress and societal benefit, and this is likely to differ strongly across different countries and cultures."

Ryan Sweeney, director of analytics at Ignite Social Media, commented, "Technology has the potential to further divide humans on a class level. Those who can afford the technology will have significant benefits from wealth-maintenance to extension of life. Those who cannot afford the technology will likely remain disconnected or will not receive the same level of service as those who can."

Ian O'Byrne, an assistant professor at the College of Charleston whose focus is literacy and technology, said, "The main challenge is whether or not we have the social, political and educational imagination to adapt and effectively use these technologies. If we do not (and history has shown this again and again), then a relative few will be able to leverage these new powers and tools, while the remainder may be worse off for it."

A policy director with the European Commission wrote, "Millions of people in the world still do not have access to clean water, education, clean energy, fast and cheap communication and the health and welfare benefits that are associated with that (not to mention economic growth and job potential)."

Denise N. Rall, a professor of arts and social sciences at Southern Cross University, Australia, responded, "It is more likely that some climax will come, in a semi-apocalyptic scenario. The world's resources cannot continue to support 'life as we know it.' If people continue to pursue digital realities over real-life realities – that is, too many people to feed and not enough resources to do so, plus the ever-widening gap between rich and poor – any kind of internet-based interactions will come under threat as our physical environment continues to deteriorate around us. Generally, technology has made things better for the 'haves' and rarely, with a few positives, such as the Grameen Bank, for the multitude of poor. Over 1 billion people live on less than $1 U.S. per day, and between 20 [million] and 50 million people are housed in refugee camps, without hope of permanent homes. Until these trends can be reversed, internet-based technologies will become secondary to overwhelming necessities of maintaining life for those on this planet. I cannot see any technological solution to this issue, as the wealthy may have increased digital access and employ digital servants, but this will not improve conditions overall. In Australia, we are suffering again from prolonged drought, and the simple fact of growing food is becoming precarious in many parts of the world, while population continues to climb. There will be significant benefits from technology for the wealthy, and significant drawbacks to the poor. Therefore, saying 'each individual' is a meaningless parameter for this question. Some percentage (1% to 10%) will be immeasurably richer in their employment of technological solutions, the vast majority will not."

Peter Asaro, a professor at The New School and philosopher of sci-tech and media who examines artificial intelligence and robotics, commented, "The penetration of the internet deeper into the physical and social world will benefit some greatly, many to some degree and most little or negatively. Most of the benefits will go those who have already benefited from the internet. Some benefits will be derived from aggregating and analyzing the collected data, but few people will see the connection."

Joshua Loftus, assistant professor of information, operations and management sciences at New York University and co-author of "Counterfactual Fairness in Machine Learning," commented, "I expect inequality to continue growing in each new dimension. For many in the world it will be a long and drawn-out apocalypse. For others it will be an augmented reality wonderland of hyperstimuli and consumption. It will be better for some and worse for others. For non-humans, for example, mass extinction will probably accelerate."

Simeon Yates, director of the Centre for Digital Humanities and Social Science at the University of Liverpool, said, "I sadly believe that we will see a world of digital haves and have-nots – where the majority have access but utilize a limited set of services (as is the case with written literacy)."

An associate professor of sociology at a major university in Japan responded, "The digital divide will become a more serious problem. Most tech companies will make apps and digital tools for people who easily utilize internet and digital devices and also for English users. This creates an illusion of ubiquitous internet, but the infrastructure will tend to be made for only those people. This could create huge social problems."

A program director for technology at a U.S. Ivy League school said, "Adoption of technology will be uneven, and the rich will get richer. Surveillance technology will keep the masses from organizing for social and political movements. The rich will get richer."

Life will not be better for most individuals if current trends expand, extend

A number of respondents expressed concerns over the power of large technology companies, the rise of platforms that offer services in exchange for data and marketing dollars, the potential for growing lack of human agency in the algorithm age, the potential loss of jobs as humans are replaced in workplaces, and other worries over emerging potential negatives of digital life.

Amy Webb, founder of the Future Today Institute and professor of strategic foresight at New York University, commented, "In 2018, there are nine companies (which I call the Big 9) that control the future of humanity, because they are building the future of artificial intelligence. Over the next five decades, we will see widespread consolidation in the fields of AI and digital platforms. We'll trade convenience for choice and find that we have far fewer options for everything, from how fast to drive in our cars to which restaurants we'll choose for dinner. Our professional and personal lives will be tethered to a provider – likely Amazon or Google – which will maintain and run our smart homes, hospitals, schools, city infrastructure and offices. We will probably see a vast new digital divide: The wealthiest among us will have the privilege to remain anonymous if they choose, while everyone else will submit to continual surveillance for marketing and business intelligence. Importantly, during the next five decades, America will have fallen far behind China,

primarily because of China's long-term, comprehensive AI strategy and its integration into other state-level initiatives. In the U.S. commercial interests are what propel AI, platforms and digital media. The interests of for-profit companies don't necessarily align with the best interests of democracy, our country or humanity. With significant investment in these fields, there is tremendous pressure to generate commercial products and services, and the speed required doesn't leave room to ask critical questions about a technology's impact on individuals, communities or our society. If we do not change the developmental track of AI in the present, the probability of negative scenarios will increase during the next 50 years. Collectively, we fetishize the future. Few are actively mapping longer-term outcomes, and that is a big mistake."

Anita Salem, systems research and design principal at SalemSystems, wrote, "Without a concerted effort to design these new systems ethically and responsibly with a goal of improving the human condition, we will see a world of increasing power disparity with capitalism and corporations at the top. Worldwide, we already see a rise in authoritarianism, a weakening of democracy and the dominance of transnational corporations. In the United States, we are also seeing a shift in demographics and economics that looks to further weaken democratic ideals of freedom (but not for people of color), identity (a corporation has human rights) and free speech (journalists are the enemy of the people)."

Roland Benedikter, co-director of the Center for Advanced Studies at Eurac Research Bozen, South Tyrol, Italy, responded, "The overall problem is democracy. The internet as we know it has been invented by and within open societies. If there will be a multipolar global order in the full sense, it might be partially nondemocratic, thus lowering basic rights and opportunities as compared to now."

Simeon Yates, director of the Centre for Digital Humanities and Social Science at the University of Liverpool, said, "I see a much greater commercial role in the digital sphere unless net neutrality can be enforced. As more of the internet is served up through walled garden/gated community platforms and apps – digital places whose access is commercially or organizationally constrained – there are inherent threats to open society and democracy. This is ironically the opposite of the hopes of the internet's founders and first users. If we want to see an internet for all – for the many, not the few – we need to realize that this will need regulation and policy. I see the internet becoming ever more part of politics and policy on many fronts therefore."

Jillian C. York, director of international freedom of expression for the Electronic Frontier Foundation, commented, "I expect to see the world's platform companies break up, and a more diverse array of platforms to enter the market. This may lead to more silos, but it could also create safer spaces for communication for various communities…. As for laws, it remains to be seen – but I worry that if our democracy continues down the road it's on, the internet will suffer."

Danny O'Brien, international director for a nonprofit digital rights group, commented, "My hope will be that these tools will be at the control of individual users, not hidden or concentrated in smaller, more powerful groups."

Kenneth Cukier, author and data editor for The Economist, commented, "These tools in the hands of the populists and authoritarians of 2018, in 50 years' time, mean that if safeguards are meagre, a surveillance state is possible. Freedom might be winnowed even if most people feel better off. This could be a horrible irony."

Andrian Kreye, a journalist and documentary filmmaker based in Germany, said, "Current conditions will solidify monopoly capitalism, making it harder and harder for users to escape the grip of the grid and for newcomers to break into the business. The internet as we know it in 2019 is the basic structure for a world based on an AI-driven infrastructure…. User interfaces will be speech- and thought-based, turning users even more into nodes of an ever-expanding network. For most people, these technological advances will increase convenience and ease of use. For corporations using networked AI this will mean a wealth of data and constant contact with a consumer base that can be steered and nudged with increasing ease."

Jonathan Taplin, director emeritus at the University of Southern California's Annenberg Innovation Lab, wrote, "At the very moment when the bottom-up networked revolution is affording us the opportunity to disperse power closer to the people, both our politics and our business are concentrating power in fewer hands. We can change this, but we need to act now."

Brian Harvey, lecturer on the social implications of computer technology at the University of California, Berkeley, said, "Just in this past year, there has been a big increase in popular understanding of who profits from social media technology. If that new understanding leads to rebellion, perhaps the internet can return to the anarchist utopia that was first envisioned. But if it fizzles out, people will still be bought and sold by social media."

Peter Levine, associate dean for research and professor of public affairs at Tufts University, wrote, "Right now, the internet seems to be eroding journalism as a profession, giving a few big companies and governments (like China's) more social control, and balkanizing citizens. Those trends may continue, or they may provoke a civic backlash that yields a better internet."

Mauro D. Ríos, an adviser to the eGovernment Agency of Uruguay and director of the Uruguayan Internet Society chapter, responded, "The internet will reach very advanced technological development but will lose freedom due to economic and political interests over the network. It is possible that the international community will develop a parallel network or

establish technical environments on the internet that are beyond the control of governments or organizations."

Christine Boese, digital strategies professional, commented, "Most algorithms [now being] used are shortsighted, flawed and reductive, but so 'black box' that no one has the expertise to check the work! There is enough tech available for humans to do destructive things, including destroying their own technological infrastructure. There are a number of bad actors on the human stage with outsize resources and ill intent, in this new Gilded Age created, not by technology, but by changes in government policies. Note the number of super-rich people building elaborate bunkers and compounds for themselves and their 'servants' if you doubt where the hoarded wealth of this planet believes the future is heading. We are living out a nightmare as analyzed by Jared Diamond, more resembling Western Europe's 'Dark Ages' of feudal castles, keeps and moats. With a vanishing middle class and extreme polarization of wealth and poverty, the super-rich have no intention of investing in a networked infrastructure that serves anyone but themselves."

A professor of computer science expert in systems at a major U.S. technological university wrote, "On the one hand, the future technological changes will lead to positive societal changes, if the political power in control of knowledge is benevolent and progressive. On the other hand, if the political power is repressive (e.g., the Orwellian vision described in his book '1984'), then the technological changes will result in significant negative changes, possibly a dystopian society. In other words, technological changes are enablers that can be used for good or for evil. The question of whether they will better or will worsen an individual's life is not a technological question, but a political one, of how technological advances will be used. My hope is that the political forces will evolve toward bettering individual lives."

Ramon Lopez de Mantaras, director of the Spanish National Research Council's Artificial Intelligence Research Institute, said, "Unfortunately, with the arrival of the internet we did not only open a box that contains good and positive things. We opened a box that is causing lots of problems. We are living in an accelerated pace that leaves us less and less time for reflection. We are on a train running at very high speed that is taking us nobody knows where. Are we happier now than 30 years ago? I do not think so! And when one reads about the social credit initiative in China one should be really afraid. In summary, there will be more stress due to living an accelerated life and real threats to our freedom and privacy."

Mike O'Connor, a retired technologist who worked at ICANN and on national broadband issues, commented, "I'm deeply pessimistic about the future of the planet in general and digital life in specific. The undercurrent of the present day pits earnest volunteers (like me) against ever more sophisticated and well-funded corporations and governments. I believe that 2050 will find us in a dystopian environmental nightmare in which the internet I love has become a devastatingly

powerful tool of suppression and mind control. The next 50 years will see the end of the Enlightenment and the Renaissance and the descent back into a much more authoritarian era. Techniques being beta tested in current politics (e.g., Russian meddling, Brexit, Trump) will be viewed as unsophisticated trial runs of control technologies built by the very best minds – people who are well compensated for their efforts. While I'm a fan of 'plucky opponents,' I don't believe the forces of good stand a chance against the gathering intellectual and ethical darkness."

Ken Birman, a professor in the department of computer science at Cornell University, responded, "Bill Gates often points out that by any statistical metric you can define, global quality of life and also quality of life in the Western world have risen enormously for many decades now. I see no reason for this to change in the 2050 time period, with one major exception: Some countries, notably China, seem to be viewing the internet as a massive technology for spying on their own population and on much of the rest of the world. Russia seems to view the internet as a playground for disruption. North Korea has used it to extort money and to harass their enemies. So I do worry that research on strong ways to protect security and privacy, and to protect against intrusion, needs a great deal of additional emphasis and investment, to enable the bright future Bill Gates sees and also to protect against this sort of harassment and meddling."

An engineer and chief operating officer for a project automating code said, "The internet will become a highly regulated and monitored form of communication with its main aim to promote consumerism. People's use of it in seeming information will be mined to an intimidating extent, putting severe limitations of personal freedoms. People wanting social change, which will mean equity and justice will withdraw from electronic communications. The use of encoding will eventually be made illegal except for those with sociopolitical power."

An expert in algorithms and bias and assistant professor artificial intelligence at a major European university wrote, "At some moment the question of who owns or controls the algorithms will become the prime question for humanity, and at the moment algorithms will become uncontrollable by humans we will face a whole lot of other questions. Whether that will happen in the next 50 years or earlier, or later, who knows? But, that there is this trend of algorithms replacing/controlling any interaction between humans and the world (and other humans) is undeniable and already happening: Facebook controls much of our social communication, Google manages our lives and information consumption, Twitter mediates our chit-chat, and with the rise of modern smartphones the control of visual information (e.g. Google Lens) is coming. And this is just the beginning. Algorithms will take more control over our lives (health, music preferences, job choices, satisfaction, etc.) and the world (markets, cities, deployment of resources and much more)."

One of the world's foremost experts in the sociology of human-technology interaction said, "I fear not only an integration but surveillance so that there is a chill on political and social expression. Already you see the start of this kind of regime in China. Social control in exchange for convenience is what I mostly fear."

What's going to happen if humans become cyborgs or AI gets smarter than us?

A share of respondents reflected on the potential dark side of recent innovations – a world in which neural implants help connect people's brains to the internet – and shared concerns about the prospects of technology moving toward and beyond human-level artificial intelligence.

Steven Thompson, an author and editor of "Androids, Cyborgs, and Robots in Contemporary Culture and Society," wrote, "I expect a dystopia to rise out of the consequences of the internet appliance moving into the human body. That is a game-changer from economies to personal liberties and everything in between…. [O]nce the internet in inside you, and that's prior to 2030 even, you are no longer strictly human, so all of the necessary structures for sustainment of you as the creature will change the future for mankind as a species…. [I fear] a sentient internet."

Frank Tipler, a mathematical physicist at Tulane University, commented, "We may see humanlevel AI within 50 years. Once the human level is reached, AI will automatically take off to superhuman levels. Humans will cease to be the dominant life form in the universe. If humans accept their loss of being the dominant life form, then AI technology can raise human standards of living. If humans join AIs as downloads, this will also be good. But if humans decide to make war or enslave the AIs, it will be very bad. I'm optimistic, hence my answer that internet evolution over the next 50 years will be mostly positive in individuals' lives."

Erik Huesca, president of the Knowledge and Digital Culture Foundation, based in Mexico City, said, "The greatest point of tension between humans and intelligent entities (not necessarily robots) will be the values of our current society, privacy and respect for democracy and the diversity of communities and cultures. If systems whose objective is efficiency interact in the social field with humans, there can be seeds for the type of totalitarianism that we are seeing today. The idea of the individual in societies highly linked by networks can disappear. Technologies will be aimed at development of superhumans with genetic modification. (It is cheaper to modify an organism than to produce entities from other materials.) The values of human life will change. The new sciences of life will be the key point of knowledge development."

Frank Feather, futurist and consultant with StratEDGY, commented, "Thinking ahead 50 years, it is highly likely that DigiTransHumanoids, who will replace humans as a species, will be able to network and communicate directly with each other on a brain-to-brain basis, via the cosmic

wavelengths that carry today's platforms. As such, no platforms will be needed. There may well be a Google-like cosmic platform that prevails if Google itself transforms itself into that platform. We need to understand that each and every technology is an extension of the human species and its abilities – abilities that are vastly underdeveloped. DigiTransHumans will be vastly more advanced in our next evolution, and they will unify this planet and reach out into the cosmos from where they first originated."

Michael Dyer, an emeritus professor of computer science at the University of California, Los Angeles, commented, "One of the greatest existential threats to humanity will be, not AI, but General Artificial Intelligence (GAI). Our humanity is based in our bodies, not our minds (when comparing ourselves to synthetic entities with similar or greater mental capabilities). Synthetic GAI entities will not be born; they will not grow from children into adults; they will not grow old and die. They will not urinate or defecate. They will not have sex. Change the embodiment of mind and you change what it means to be human. GONE would be the following: Disney movies (since no children), romantic novels (since no sex) and all experiences based on bodily desires (recharge batteries vs. good meal at a restaurant). If GAI is allowed then elimination of humanity will occur, either via general spread of GAI entities or by development of a single, super-intelligence GAI."

Alexey Turchin, existential risks researcher at Foundation Science for Life Extension, responded, "If there will be life on Earth at all, that is assuming a positive outcome, we will live in the world dominated by global benevolent superintelligence, where there will be no border between VR, AI and individual minds of fleshy humans and uploads."

Anita Salem, research and design principal at SalemSystems, shared a dystopian post-human scenario, writing, "In 50 years, digital tools, if used at all, will be used for entertainment only. Video and chat apps will be created by the corporate powers to shape opinions and behaviors of the masses and will be widely and publicly displayed. The Dark Web will be alive as a black market and revolutionary system used by the outcasts. Organic/chemical communication systems will be used by corporations for real work and they will form the underlying structure of computing systems. They will be embedded in everything, including humans. This will be the 'post-human' era, where the human/machine interface is embedded at birth, invisible and pervasive."

What if having less work leads to the opposite of the ideal 'life of leisure'?

A share of respondents shared thoughts about a world with fewer jobs for humans.

Mark Maben, a general manager at Seton Hall University, wrote, "Right now, we are illprepared to manage how artificial intelligence will disrupt the nature of work across the globe, both emotionally and institutionally. Humanity has to plan immediately for the loss of literally billions of jobs around the world as AI and automation replace people in all types of work. This

means governments must step up to provide for displaced workers through benefits like a universal basic income, health care, retirement security AND guiding people to accept a new definition for what it means to perform meaningful work. Parenting, volunteering, lifelong learning, mentoring, leisure, artistic creation and other pursuits must be raised in stature and acceptance. But the response to economic disruption so far has been nationalism, authoritarian, scapegoating, violence against 'the other' and denial of what's to come. While I believe in the potential for technological progress to improve our lives, I lack faith in our ability to successfully manage that progress for social good. As E.O. Wilson wrote, 'We have created a "Star Wars" civilization, with Stone Age emotions, medieval institutions and godlike technology.' That's a dangerous combination, one that presents a real risk for individuals."

Justin Amyx, a technician with Comcast, said, "It can be potentially catastrophic to low-wage, unskilled workers. Without a plan to do something to mitigate that displacement – of machines taking people's jobs – poverty may prevent access therefore stifling growth. If we do resolve to account and accommodate for these potential issues there is no telling where technology can possibly go."

Marc Noble, a respondent who provided no identifying details, commented, "AI, if properly developed, will take over a lot of jobs. A lot of IT positions will disappear; programming will be relegated to a very small number if at all. AI will develop its own language and communications channels that will be faster, more efficient and a lot more secure. The need for old industries and fossil fuels will be sharply curtailed."

Johanna Drucker, professor of digital humanities in the department of information studies at the University of California, Los Angeles, suggested a movement toward planned creation of nontechnological job positions as work evolves. She wrote, "Distributed computing, embedded into 'natural' interfaces, will create a seamless integration of access to networked information and experience in the physical, analog world. The hazard is that the greater the integration, the higher the risks of codependence. I would advocate for physical labor (urban gardens and forests, elder care, child care, local food production and preparation) to be part of the emerging social structure. Free human beings from labor that is meaningless, but give them work with a purpose. Keep in mind that skills like plumbing and electrical work cannot be outsourced and that infrastructure is massively physical and built on stacks of systems that have to work together. We should always have a way to sustain ourselves without networked technologies. Reduce our path dependencies, fragment the supply chains, resist monopoly controls, change the values of the culture toward sustainable and equitable human and animal life. Someday the idea of huge profits and private control of massive wealth will look as grotesque as the idea of heads on pikes and guillotines do now."

An assistant professor of social justice based in the U.S. wrote that in a world with fewer jobs for humans thanks to networked AI and other transformations, "Technology will end humanity, as people will no longer strive to be the best they can be."

Who's really in charge here – humans or automated digital systems?

Concerns over slipping into a world with no real human agency were expressed by some respondents.

Marc Brenman, managing partner at IDARE LLC, said, "The internet will become transparent to us. We will think our way through it, using implanted devices. There will be no privacy. Everything will be remembered, and there will be no forgiveness. Virtual reality will become reality. The very concept of 'virtual' will almost disappear. People will be able to distinguish fact from fiction even less than we do today. Unscrupulous people will use this technology to create our obedience. Free will will be eroded. We will surrender even more of our time to bread and circuses, celebrities, puppies and kittens. We will live so long that life itself will be a burden. Machines will do everything better than we can, including creating art."

An assistant professor of social justice at a U.S. university wrote, "People will become helpless and rely on tech for almost everything. Tech will take over almost all routine activities, but this will not empower most. Rather, tech will serve as a prison."

John Sniadowski, a director for a technology company, wrote, "To the vast majority of internet users, the internet is akin to making a cup of tea. You simply want to fill the kettle from the tap, switch on the kettle, boil the water and pour it onto the tea. They don't ever think about the infrastructure that makes that possible. This means that people will adopt any internet that makes life easier without thinking of the consequences."

An anonymous respondent wrote, "I fear that we will end up in an extremely dystopian situation where autonomous AI makes decisions for society with significant disparities between the haves and the have-nots. This is not inevitable, but I think controlled self-learning and selfmanagement is necessary for a beneficial contribution to society."

A strategy consultant wrote, "People will lose individuality and cultures will die, merged into one Eurocentric mass with threats to trade, aid and international access. Minorities will be corralled and shamed online into silence and acceptance as online speech and media overwhelms typical law. Copyrights will be enforced beyond fair use, leaving entertainment and information heavily blockaded from the poor."

An anonymous respondent predicted that the public will just tune into entertainment to cope with the new realities of this dystopia others have described, writing, "Oh, brave new world that has such addictive pacification tools available. People will not be better or worse off. They will be distracted from their situation with individualized circuses."

Corporate self-regulation is seen as unlikely remedy due to market capitalism

The 50th year of computer networking has been one of commonly expressed disillusionment with the current state of affairs online. A large share of respondents to this canvassing say that profitbased enterprises' domination over the network of networks and thus the world – now and in future – is what concerns them most.

Cliff Zukin, professor of public policy and political science at the School for Planning and Public Policy at Rutgers University, said, "Looking backward, there are two axioms that have stood the test of time: 1) Information is power and 2) Power corrupts. Fifty years into the future – by then I expect everything will be global and individual at the same time – we either won't be here, or we will have figured it out. If we figured it out, there will be no independent states, nor much difference between human and robot. All big players will be multinational corporations. Borders won't exist; countries electing their own leaders won't exist. We will have a governance structure of the internet determined by those powerful enough to make that happen. In other words, the Empire will win."

Douglas Rushkoff, a professor of media at City University of New York, responded, "When technological development is determined solely by the market we get some unintended consequences. Barring a major shift in emphasis away from corporate capitalism, the benefits of any technological development will probably be determined by how aggressively one company or another pursues its goals. Some technologies will be less bad, because the manufacturers want to be less harmful. But even those outside traditional venture funding, who attempt to create beneficial technologies, will be subject to the supply chain and platform limitations of the mainstream technologies. So it's going to be really hard to develop any capital-intensive tools that don't serve capital over people."

Christian Huitema, internet pioneer and consultant focused on privacy online, previously Internet Architecture Board president, chief scientist at Bell Research and Microsoft distinguished engineer, commented, "We developed a wonderful communication technology only to see it captured by large corporations and governments. It will take several generations for humanity to regain control.… The ad-funded business model evolved in generalized corporate surveillance. It requires more attention to drive more revenue; AI-driven user interactions are providing that. This AI + ads feedback loop is creating digital drug addicts."

Seth Finkelstein, consulting programmer at Finkelstein Consulting, commented, "I, for one, welcome our new platform overlords. I see almost no check on the tendency toward monopoly control, or at the very best, oligarchy involving a handful of corporate behemoths. It's sobering to realize that the very few serious restrictions that exist come from major nation-states (i.e., China's own desires for internal control). That's the level of power needed for an effective opposition. Looking at the history of the 20th century, it's entirely possible that the 21st century will see some massive convulsion similar to the Great Depression or a World War. And the aftermath of that event (presuming civilization still exists) could entail strong antitrust laws that would severely limit the data-mining business models of many of today's major internet companies. It'd be a horrible way to get that outcome, but if the past is any guide, one of the few ways it would ever happen."

Walid Al-Saqaf, senior lecturer at Sodertorn University, member of the board of trustees of the Internet Society, commented, "With consolidation on the internet as an ongoing threat to democracy and fairness to citizens, there will be a greater tendency to move to alternative decentralized solutions that aim at empowering citizens more directly as bitcoin did. That being said, I expect a pushback by governments and conglomerates that will fight to remain in power, leading to an inevitable clash of wills. At the end of the day, it will be mass adoption of which technology that will determine who will win."

John Leslie King, computer science professor, University of Michigan, and a consultant on Cyberinfrastructure for the NSF CISE and SBE directorates for several years, commented, "It is hard to know exactly what will happen with power-reinforcing technologies in a climate that is tending to exacerbate wealth and income inequalities, given the proven influence of wealth and income on the social order. It is not crazy to imagine IT reinforcing the power of an elite that already has a lot of power, especially if that elite tends to be aggrandizing power to begin with. Many IT proponents think that some version of libertarian utopianism will arise to save the day by taking power from 'the man' and giving it to 'the people.' In my experience, 'the man' doesn't want to lose power to 'the people' or anyone else. It is a mistake to think of technology as changing anything. Technology is, at most, one of several powerful forces that shape things."

Michael Veale, co-author of "Fairness and Accountability Designs Needs for Algorithmic Support in High-Stakes Public Sector Decision-Making" and a technology policy researcher at University College London, responded, "As more and more tasks and interactions move online, political battles will become increasingly about the governance of the internet. The interconnectedness of this policy area means that new democratic institutions will be needed that are more global in nature. Some old-style, exclusive, powerful networks will find new forms online, as a new political elite are 'digital-first.' A consistent battle between centralization and decentralization is likely to continue, with AI tools enabling individuals and small firms to make

and connect compelling services, and the value-add of a large design and management bureaucracy like Facebook will decrease. Competition rules might be in place to force services to work with each other, and the failure of the ad-supported funding model will mean that individuals are often paying a premium for enhanced access to exclusive networks of people and activities."

A professor of computing and digital media expert in in artificial intelligence and social computing predicted, "The trends around democratic governance of technology are not encouraging. The big players are U.S.-based and the U.S. is in an anti-regulation stance that seems fairly durable. Therefore, I expect computing technologies to evolve in ways that benefit corporate interests, with little possibility of meaningful public response. As such systems take in more data and make bigger decisions, people will be increasingly subject to the systems' unaccountable decisions and non-auditable surveillance practices. Soshanna Zuboff's term 'surveillance capitalism' describes this state of affairs."

A well-known journalist, blog author and leading internet activist wrote, "The future of technology depends on our willingness to break up the digital monopolists and reinstate the antitrust measures that prevent predatory pricing, market-cornering and other anticompetitive actions. In particular, companies must not be able to convert their commercial preferences against 'adversarial interoperability' (when a competitor or toolsmith makes a tool that modifies their products and services to make them better for the users, without the service provider or manufacturer's permission) into a legal right to invoke the state to punish competitors who engage in this conduct."

An anonymous respondent said, "Neo-liberal economic policies are resulting in increasing inequality and are unsustainable. If current trends continue, we will be living in a frightening dystopia, where personal data is collected and monetized by a small number of giant companies."

Sanjiv Das, a professor of data science and finance at Santa Clara University, responded, "Technological revolutions improve the world not because they offer cool new toys but because they improve lives with better use of information…. These systems implement control through inequalities in knowledge, which lead to inequalities in wealth. Advances in technology unaccompanied by enlightened politics may delay progress and create turmoil in the short run. It may take a mutiny by a tech elite to move things forward in the right direction."

Larry Lannom, internet pioneer and vice president at the Corporation for National Research Initiatives (CNRI), an expert in digital object architecture, said, "I am an optimist and I hope all of these advances will, overall, be for the better. But I worry about the ownership and use of ubiquitous computing and network technologies – will they be used to control the masses for the

benefit of the few or will the benefits apply to all? It will almost surely be a mix of the two and we should be working today to ensure that the balance of advances will go to improving the general welfare."

Serge Marelli, an IT security analyst, predicted that the future will bring, "More porn, more advertising, less privacy, fewer users'-citizens' rights (e.g., right to privacy), more money for big corporations. And politics and democracy will fall short."

Joël Colloc, professor at Université du Havre Normandy University and author of "Ethics of Autonomous Information Systems: Towards an Artificial Thinking," responded, "The internet is no more than a tool of business polluted by advertising, and internet users are seen as customers to target with CRM and the place of the trade. This evolution is irreversible. The internet has become a space without ethics where the user is subjected to predators in a lawless, wild world. The netiquette rules must be updated to protect the rights of users and protect them against business spamming, which has become a plague."

Manoj Kumar, manager at Mitsui Orient Lines, responded, "Advancement of knowledge/information availability has not only empowered humanity; it has also bewildered it.

Rights are being abused. Commercial aspects are being hijacked by few strong companies, depriving the rest of fair opportunities. At some point, government and the public will have to rethink the options and ways of limiting their reach. Amazon and Alibaba will need to become more decentralized, less encompassing and less pervasive than what they are today. Google will need to scale back its analytical reaches to provide the freedom of choices…. The proliferation of the services sector is leading to erosion of the infrastructural economy, which is not sustainable. The coming years will require correction to these uncontrolled advancements in the digital world. The excesses of free access, unchained commerce and capital-free digitalization must be checked and the human element enhanced to provide the balance of the digital with human growth so that they are sustainable in the coming century."

Wangari Kabiru, author of the MitandaoAfrika blog, based in Nairobi, commented, "As we have more owners of democracy through the net … this will result in new super-powers being created – now not nations but individuals and corporations."

An assistant professor of media studies at a major U.S. university commented, "So long as the political economy of the internet is shaped by surveillance and the extraction of personal data from users who have no recourse, any democratic potential of these new communication technologies will be squandered."

A professor emeritus at a major U.S. university's school of information responded, "I remain hopeful, yet I am pessimistic. The U.S. form of capitalism has 'won'; variations of it have been adopted in virtually all nation-states. It has yielded extraordinary technical innovation and economic development, progress in health care and medicine and overall improvements in living standards. Yet the benefits of this economic infrastructure are unequally distributed among the global population, and currently this benefit inequality seems destined to widen. Without a revolution or upheaval in values and structures, we can posit that AI becomes increasingly embedded in existing corporate/government organizations. With this evolutionary movement, the emergent structures can continue to become more centralized. The increased centralization of power is likely to be manifest as the larger platforms (corporate or government, the boundary may become more porous or blurred) exercise their economic power with greater control of individual choice and behavior. The control might be exerted either through a 'Big Brother' model, with more personal intervention at the highest level or a more Kafkaesque model, with AI aiding governance systems to make decisions using complex and hidden algorithms whose origins and evolutionary paths are not evident and can't be dissected and understood."

An infrastructure engineer for a leading social network company commented, "The push to monetize every aspect of digital life will continue, potentially causing large disruptions in the way we live. Not all these disruptions will be for the positive, particularly in the areas of human dignity and worth. As humans increasingly rely on social networks to make decisions, they will find themselves unable to resist the 'mob of the moment,' which will cause political and social problems far beyond our current ability to manage. These problems may well be met with attempts to 'regulate' expression to prevent mob actions from occurring, which could, in turn, lead to lessfree societies – the opposite of what was intended in the invention and fostering of these technologies. The law of unintended consequences is likely to show itself in many other aspects of our lives, from sexuality to social order. We are building highly complex systems for one purpose, and failing to realize that complex systems, and their social offshoots, have unintended consequences far larger than anything we can imagine. The backlash to these movements, once the unintended consequences set in, are far greater than imagined, as well. The initial goals are often mixed, causing both a gain and loss in human dignity; the backlash is often mixed, as well. Whether dignity ratchets up or down is an open question at this point, but right now we are seeing human dignity ratcheted down, with human life being devalued en masse. The problem of 'content wants to be free' will need to be resolved, as well; if content is free, then the human effort put into creating that content is useless. This would reverse the trend of thinking being more important than doing, and virtual products being more valuable than physical ones. Until the worth of human effort can be balanced against the ability to move and copy information freely, the problem of paying people to create will remain."

Some express the hope that the troubled times they foresee coming over the next few decades will eventually be overwritten by new social, economic and political processes and forces.

Ian Peter, pioneer internet activist and internet rights advocate, said, "The internet, after a period of utopian visions for a form of media that enhanced freedom of expression and communication, and improved access to information has followed the pattern of most forms of mass media by becoming dominated by a few players. As part of this domination a new financial model has emerged where internet users are the commodity, with their free or cheap usage funded by the use of their personal data for a variety of commercial uses. It is hard to see a change to this model occurring in the near future, and the internet as we know it is likely to continue this pattern for the rest of its lifetime. However, the internet will in time become old media like radio and television: New forms of media will emerge, and they are likely to be disruptive changes rather than some type of incremental development."

Yvette Wohn, director of the Social Interaction Lab and expert on human-computer interaction at New Jersey Institute of Technology, commented, "Despite the internet being a system that enables peer-to-peer interaction, in the past 50 years we have seen it enable the corporate broker in scales unprecedented. Amazon, Facebook, Spotify and Uber are just few examples of these brokers. The roles of these brokers will slowly change so that they have less power and decentralization will bring back individual and small businesses."

Sasha Costanza-Chock, associate professor of civic media at MIT, said, "Here I'll offer an edgecase *optimistic* scenario. In 50 years, very high-speed symmetrical network connectivity will be freely available to all humanity, served by a mix of satellite, municipal networks and communitycontrolled cooperatives. For-profit ISPs will be a thing of the past. In a similar vein, key platforms and features of the net will no longer be controlled by for-profit companies. The dominant search engine will be run by the Wikimedia Foundation, in partnership with the United Nations. Social networking sites will be predominantly decentralized, federated, interoperable and powered by F/LOSS (similar to the way email functions, with many different providers, or the option to host your own, that all communicate with one another). Important services that benefit from network effects will be controlled by municipalities; for example, OpenHail ridesharing standard will be mandated by most municipalities so that ride services are no longer controlled by one or two large firms. Airbnb will be largely replaced by OpenHouse home sharing/hostel standards that enable many players in the market. Most importantly, new applications and services, and improvements to existing applications, will largely be developed through co-design methods that include intended end users in all stages of the design process. Co-design, or design justice, will have long since become the standard best practice across all areas of technology design and development. All AI and algorithmic decision systems will be monitored through standing

intersectional audits by independent third parties and/or state agencies to ensure equitable distribution of outcomes rather than the reproduction of bias."

An anonymous respondent said, "It is my hope that platforms/giants like Facebook, Google and Apple take more responsibility for their intrusion into our lives."

Digital experiences threaten authentic human interaction

A share of respondents envisioned a future for many humans of self-imposed isolation in virtual worlds or personalized online algorithm-avatar-based relationships that seem more attractive than real-world, in-person social interactions. Some are concerned that the many hours people spend in controlled digital environments will influence them in a negative manner.

Luke Stark, a fellow in the department of sociology at Dartmouth College and at the Berkman Klein Center for Internet & Society at Harvard University, wrote, "Increasingly ubiquitous digital systems will do a good job of cocooning individuals within personalized augmented reality bubbles, but a terrible job at facilitating durable connections between us. At the same time, those connections will be surveilled, measured, tracked and represented back to us in ways that will aim to make us more economically productive and socially pliant in the guise of 'wellness' and 'community.' These systems will increase social inequality through their dividuating effects and contribute to environmental degradation through their use of natural resources – a Philip K. Dick dystopia come to banal life."

John Lazzaro, retired professor of electrical engineering and computer science, University of California, Berkeley, commented, "Fifty years from now, we will return to Steve Jobs' original vision of computers as bicycles for the mind. As someone whose first job in technology was stocking shelves in a Radio Shack, years before the first personal computer appeared in the store, I am lucky enough to remember life before Steve articulated his vision. I then watched the vision's ascent, and its current fall from grace. Today, as I walk down the street, and see people walking with their attention captured by their phone screen, I wonder how it all went so wrong. The only thing more depressing is the content that appears on their screen, and the cultural impact that the content has on us all. I believe the way forward starts with an acceptance of the human condition: We are an easily addicted species, and our evolutionary survival depended on prioritizing 'thinking fast' over 'thinking slow' in many contexts. Today, from the application user interface up to the economic ecosystem, platforms often exploit human foibles for profit, just as Marlboro Man and Virginia Slims billboards did in the 1970s. The first step in the journey of the next 50 years is reaching a consensus that an addictive approach to the digital world is not sustainable. And that the profit motive, like discipline, is a means to an end, and not an end to itself (to paraphrase Robert Fripp). Technology options can inform the journey's second step. On the device level, Mark Weiser pointed us to the right direction with the concept of ubiquitous computing in 1988, and the

many iterations of this concept in the decades since provide a good foundation for a world where a computer is not a cigarette. The mature mechanical devices (for example, venetian window blinds) and electro-mechanic devices (for example, electric shavers) in our lives do not foster addictive responses, and have benign business models. If we rethink the 'how' and the 'why' of digital devices in our lives, we can remake them in the same positive way."

Eliot Lear, principal engineer at Cisco, said, "On the whole the internet has proven to be a wealth of knowledge and entertainment. But it has also isolated us from our local communities."

Ian Peter, pioneer internet activist and internet rights advocate, said, "We cannot dismiss two key factors in the current spread of internet usage: firstly the addictive and pervasive 'always-on' effect of unending access and multiple device usage, and secondly the effects on our capacity for critical thinking of having the 'information' we see determined by algorithms whose objective is not to inform us, but to capture or thoughts and minds. The decline of a capacity for critical thinking is a serious side effect of continued addictive internet usage that warrants more detailed scientific investigation."

Evan Selinger, a professor of philosophy at the Rochester Institute of Technology, commented, "Half a century from now, one of the biggest challenges will be what, in our book 'Re-Engineering Humanity,' Brett Frischmann and I call the right to be 'off.' Currently, it's extremely hard for many of us to unplug. Unplugging is simply a luxury that most of us can't afford. As internet connectivity expands to more and more interconnected devices, a robust Internet of Things infrastructure will keep expanding. The expansion will be fueled by a desire to acquire more personal and collective data and the ideal of ubiquitous algorithms acting upon integrated and aggregated big data will become harder to decouple from smart living. In such a world, where will people find protected spaces for thinking critically about whether they are being programmed to behave in ways that diminish their agency and capacity to determine whose interests the unshakable, augmented intelligences really serve?"

Kostas Alexandridis, author of "Exploring Complex Dynamics in Multi-agent-Based Intelligent Systems," a research assistant professor at the University of the Virgin Islands, said, "In the next 50 years digital integration will become closely integrated with almost every aspect of our lives, from our simple household infrastructure to our transportation systems to our economic infrastructure to our social systems. Digital integration will change norms and institutions the same way that industrialization and electricity was integrated to our societies and global infrastructure in the beginning of the 20th century. From smart devices to smart cars to smart wallets to digital commerce to digital democracies, it is very likely that newer generations of citizens will develop a strong and tightly integrated dependency with networked infrastructure."

Alper Dincel of T.C. Istanbul Kultur University, Turkey, wrote, "Technology's first purpose is creating benefits, so apps and programs helping people to consume more. In this point of view, companies are losing their reliability. And we are losing quality of our life. Our life will be like 1990s pop music (not 1980s) with the effects of digital age – less meaningful and more fast."

Johanna Drucker, professor of digital humanities in the department of information studies at the University of California, Los Angeles, said, "We will be shocked by the rapid acceleration of destabilizing influences and the rate at which civility can break down. Hopefully it can also be rebuilt with the same forces."

Robert Bell, co-founder of Intelligent Community Forum, wrote, "I expect ubiquitous highcapacity connectivity in the rich and semi-rich worlds, and vast increases in it for the rest of the world's people. Riding that connectivity will be learning algorithms that we integrate into our lives without a thought and deliver a vast range of services and information. Our interface with the network will evolve in ways that seem almost fantasy now. How well this turns out for us depends on getting a few things right. We must have a near bulletproof solution for security and identity online, and individual control over online privacy. Otherwise, the 'pollution' of cyberthreat, fraud and misinformation will choke off all progress. It is typically a crisis that forces us to confront the damage of such third-party effects as pollution. I have no idea what the crisis or crises will be, but as the network grows toward ubiquity, the potential damage of such a crisis grows with it. The great challenge that will come with all of this is to avoid being overwhelmed by the digital overlay of the physical world. We already see the early stages of it in daily life. I hope that humanity's ability to adapt its environment to its own needs, rather than letting the digital environment control it, will continue to shield us from the worst effects. If we give people individual choice and the power to evolve rules to guide those choices in the right direction, we will manage to extract more benefit than harm from what we do."

Dalsie Baniala, Telecommunications and Radiocommunications Regulator of Vanuatu, said, "Digital will divide lives (rich and poor). Rich people will interact with only rich people. Digital life for some people will also create artificial living and happiness. Digital life will cause no more human-to-human interactions but human machine-to-machine. Digital life creates no more human senses."

Ross Stapleton-Gray, principal at Stapleton-Gray and Associates, an information technology and policy consulting firm, commented, "I suspect that the internet will evolve toward greater robustness and reliability through, in some ways, becoming more opaque, more like a 'system of (system of systems)' than the current 'system of systems,' and partly through increased demand (for some of this infrastructure) for authentication. I would not be surprised to see it genericize from 'the Net' or 'cyberspace' or 'being online' to just 'connected,' with an assumption that unless

you were actively seeking to be 'unconnected by choice,' you'd always be connected/have connection. Like we plug things into any electrical socket without much caring how the electrons get there, we'll assume connectivity. I've written some on how humans might relate to the Internet of Things, and that vision, that humans, like cars, or buildings, or any other object, will be seamlessly interacting with all of the other things, seems likely."

Andrea Bonarini, a professor of AI and soft computing at Politecnico di Milano, Italy, said, "People will be less free and they will lose their ability to think and design, as we are already experiencing nowadays."

Alistair Knott, an associate professor specializing in cognitive science and AI at Otago University, Dunedin, New Zealand, wrote, "AI systems that understand human language have potential for both good and bad impacts on society. The technologies are likely to be developed and used by large transnational companies with the aim of maximizing their profits. The likely effect of this is that people will increasingly fall into the role of 'consumers' of entertainment-like apps that encourage political apathy and discourage individualism."

A professor emeritus expert on technology's impacts on individuals' well-being wrote, "Sadly I think we will find ourselves spending nearly all of our time immersed in internet-based activities. We are already spending, on the average, more than five hours a day using our smartphones and in 50 years smartphones will be replaced by smart devices, implants, etc. Relationships will suffer, as will our feelings of freedom. I already see the beginnings of an increased obsession to what is contained in the little box we carry with us 24/7/365 as opposed to the world that is right in front of us. It is Sherry Turkle's dichotomy of SL (online life, or a 'second life') vs. RL (real life). SL appears to be winning already, and we are talking about what will happen in 50 years. It is happening now."

A researcher and teacher of digital literacies and technical communication at a state university based in the U.S. Midwest responded, "In the future I expect to have network interactions embedded or subcutaneous on humans. We will have more interactions that are done in networked environments rather than in person. We may not even have to speak to a person for several days."

Toby Walsh, a professor of AI at the University of New South Wales, Australia, and president of the AI Access Foundation, said, "By 2069, the real and virtual world will have blurred into one. It will be impossible to tell them apart. Whilst many will spend much of their time in this digital world, there will be an analog counterculture, celebrating a disconnected and old-fashioned existence."

A digital accessibility consultant responded, "Augmented reality is likely to become part of the everyday experience. Transceivers in clothes or even under the skin will give people direct access to the internet all day every day wherever and whenever they find themselves. Thus, information will be available at all times and people will be able to control their environments through sending signals. It is unlikely that this will be done through thought alone for some time, but that is likely to come at some stage in the future. This is likely to lead to less interaction between people and certainly less personable interactions as people are likely to interact with information on the internet rather than each other. However, people with disabilities may gain somewhat as they will be able to gain access to information and services through the internet which they cannot do now because of the inaccessible nature of much of our current-day environments."

An **anonymous respondent** commented, "Connections between people are going to change. I think people will work from home more, having virtual meetings that are presented in 3D. I think this will produce a general depression among people having a lack of connection to others. In general, people will thrive; they won't have to spend time shopping, commuting and doing menial tasks. But I think we are going to lose our connection to each other."

An **anonymous respondent** wrote, "The internet will be more and more integrated in our daily lives. However, I see a problem developing. The ability to connect to people all around the world is actually splitting us into smaller groups, not uniting us."

Constant data monitoring and surveillance is a condition of hyperconnectivity

Many survey respondents pointed out that people are already trading privacy for convenience and perceived security and said they expect this trend to be magnified.

Ken Birman, a professor in the department of computer science at Cornell University, responded, "In the coming 50 years we will surely mature and invest in the needed technology to make this connected world a safer world, too. But today, that deficit stands out, and historians will be harsh when they judge us relative to this one aspect. The harm to entire cultures that oppressive monitoring and surveillance can cause is frightening, and those future historians will be in a position to document that harm – harm that people are actively inflicting today for all sorts of reasons. But I think the good will easily outweigh this harm over long periods."

A professor expert in cultural geography, American studies and gender and sexuality said, "Unless we soon make policies to regulate data collection, privacy and use as well as the policies and practices laden into algorithms (such as racism, sexism, homophobia, transphobia,

xenophobia and so on).... I fear we may wind up with a very small elite controlling most of the population."

A professor of sociology at a major U.S. university responded, "It seems likely that in 50 years there will be very few free spaces left for citizens to engage with one another without corporate or government sponsorship/surveillance. This will have implications for content and, I suspect, make it very difficult for individuals to avoid corporate advertising and governmentsponsored messaging."

Craig Burdett, a respondent who provided no identifying details, wrote, "The greatest challenge facing society is determining how much privacy and autonomy we are willing to cede in exchange for convenience and features. How much of our personal lives are we willing to share? Even in 2018 the internet is nearly ubiquitous in first world countries. Users happily allowed Uber to track them 24/7 in exchange for having a car nearby when they needed it. And we've learned that Uber is far from virtuous. New York's LinkNYC kiosks make Wi-Fi available at no cost in exchange for ad displays. And New Yorkers happily agree to the terms, which include allowing select third parties to contact them 'with … express … consent.' What feature will CityBridge offer to entice that consent? By 2069 some form of the internet will be embedded in almost every aspect of modern life. Elon Musk is already showing us how our cars will be always connected and can be updated (or disabled) without notice. And Tesla owners are happily allowing that intrusion in exchange for his cars. Extend that concept to every appliance and device we touch, from our door locks to our refrigerators, and imagine what privacy we might be enticed to give up for a smidge more convenience or efficiency. What if your refrigerator could evaluate and pre-order items before they were depleted, communicating directly with the supplier using your online account? And your front door will automatically know which delivery person (or robot) to allow inside based on the products the refrigerator (or the washing machine) ordered. Imagine never running out of toilet paper, or never again scurrying to the market at 7 a.m. for eggs. Is that sufficient incentive to share that information? I imagine devices like tablets will cease to be primarily standalone appliances. Their functionality will be embedded in homes and offices. The wall of your entryway will have a tablet that automatically adjusts the home to match your individual preferences: from adjusting the temperature in your bedroom to turning the teapot on when you arrive. And your power company will know not only when, but specifically who, is home based on that information. Each of these affordances is available by virtue of making information about your habits available to the device manufacturers. The internet, in and of itself, is benign – like a handgun. But the companies and individuals behind the services are the greatest threat."

Angelique Hedberg, senior corporate strategy analyst at RTI International, said, "Our digital footprints – intentional, unintentional and simulated – will create troves of data that will be used to model and predict our behavior and as such will be used to maximize product and control by

one or more entities. At the individual level this may feel like a loss of control. At the community and relevant transnational levels it will make room for enlightenment. We will benefit from the data of individuals we have never met just as we will be questioned about our own potential because of persons who never existed. The term for the greater good will take on new meaning as we balance personal privacy with human good."

David Brake, senior lecturer in communications at the University of Bedfordshire, UK, said, "It is very likely that the (relatively) free and open internet that flourished across much of the world in the internet's early days will continue to be threatened and, I fear, all but overwhelmed by an oligopoly of powerful platforms that will have 'captured' the time and attention of most internet users most of the time. Whether they are aware of it or not, almost everyone will live their lives continually being sorted into different categories depending on their behavior, much of which will be in some way digitally recorded, processed and shared. Some will react by attempting to remain constantly 'digitally vigilant' but this is not achievable in the long term, particularly as you will remain traceable through your interactions with others. And of course even an absence of digital profile or a carefully curated one sends its own signals."

Betsy Williams, a researcher at the Center for Digital Society and Data Studies at the University of Arizona, wrote, "Privacy will be largely a luxury of the rich, who will pay extra for internet service providers, services and perhaps separate networks that protect privacy and security."

David Sarokin, author of "Missed Information: Better Information for Building a Wealthier, More Sustainable Future," commented, "The world of 2069 will be dotted with 'privacy spaces' in our homes, workplaces and public areas. These will be rooms where people can be assured that their words and activities are not being tracked in any manner. Outside of such spaces, our current notion of 'privacy' will have essentially disappeared."

Thad Hall, a research scientist and coauthor of "Politics for a Connected American Public," wrote, "Privacy will diminish further and further as facial recognition becomes more prevalent and people can be tracked through shopping areas and other public places and their personal data from search is linked to their face persona. You walk down the street and you are presented with specialized ads on a small screen in stores as you look at a rack of clothes. Data are used to differentiate between the rich and poor, whites and nonwhites, and biases are built into every customer experience. A person's ability to be anonymous will cease and ad intrusions will become very common. These trends are likely to have political ramifications. Employers, retailers and others will be able to infer people's political behaviors – or lack of participation – from data and discrimination will occur, much as it did in the early to mid-1800s, but with greater impact."

Amali De Silva-Mitchell, futurist, responded, "When they realize the implications of data collection and profiling and tracking under various uses, people will group together to adjust to their value and comfort levels in this regard. This clustering will impact the quality of data and the quality of outcomes using algorithms. We will see tweaking of algorithms and data all the time, but poor ethics or low-quality updates are a real issue. Mobile technology in the palm of everyone's hand will result in the small minority without it living at a disadvantage although they may have a lot of privacy."

Bart Knijnenburg, assistant professor of computer science active in the Human Factors Institute at Clemson University, said, "Put the computational power, sensors and connectivity of a modern smartphone into every single object in your life. This is where I think the Internet of Things will go: You can 'ping' any object to learn its location (where is my thermos?), its status (is it full or empty?), past interactions (when did I last use it?) and connections with other devices (what brand of coffee did I fill it with and which device brewed that coffee?). It has very powerful applications, but also severe implications for our privacy. Note though that privacy concerns will not stop this future from happening. Privacy concerns have never stopped anything from happening."

Anirban Sen, a lawyer and data privacy consultant, based in New Delhi, India, wrote, "The next 50 years will have both fights over big data and privacy as well as people desiring to use new apps. How data in different jurisdictions can be used/relied will be a problem and technology will be used to also fight technology. Integration would be holistic, but it would be tough to live unnetworked."

The co-founder of an information technology civil rights program wrote, "The internet will become as ubiquitous as electricity. That means sensors will be everywhere. Governments will engage in surveillance. But the same surveillance capabilities will allow you to get immediate help from 911, for example, with the operators knowing exactly the context of the call and the situation in progress. Moreover, currently 80% of 911 calls are prank calls. That number will go down to zero. There are other examples: If your car goes off the road into a cliff and you're unconscious, the car will likely inform emergency responders automatically."

An anonymous respondent said, "Technology, and the evolution of technology, hews closely to long-standing human hegemonies, priorities and identities. We will probably be more dependent than ever on networked technologies (such as autonomous cars and mapping), but we may also be increasingly wary of invasions of privacy and the way that the data we have been donating to large tech firms can be used in service of those aforementioned hegemonies. We will be even more instantaneously connected, and machines will make more decisions for us for our convenience, but I expect that we will also have a 'reckoning moment' in which we decide that our digital footprint is

as important and protectable – as the Health Insurance Portability and Accountability Act, for example."

A principal researcher for one of the world's top five technology companies commented, "The shape of the future could hinge on whether the world moves toward autocratic rule, as in China and Russia, and now with the U.S. and other governments considering that direction, or whether it extends democratic institutions to meet challenges in a world so complex that the public can't engage meaningfully with many issues. In either case, privacy will be gone, with our lives visible to governments or corporations that – in the face of pushback such as GDPR – will raise the amount they pay us for full access. Only bad actors will refuse the offers they make; whether we will build systems to let bad actors operate with the current degree of cloaking is an open question."

A professor of information science wrote, "When I'm feeling dystopian, I see a world that looks a little too much like 'Mr. Robot' or 'Person of Interest,' with government or private organizations knowing too much about us and having too much control over us. I'd like to believe that interconnectivity could, instead, provide us with more ubiquitous access to information and with the ability to establish connections and deliver services across space and time. I hope that increases in access to information and services will enable a fairer distribution of goods and one that allows those with fewer resources to achieve success in their endeavors."

An anonymous respondent said, "The future will see our sacrifice of personal freedom as realtime surveillance becomes ubiquitous."

A professor of artificial intelligence and cognitive engineering from a developing nation said, "There will be a loss of freedom, and anything you or your relatives did or said can be used against you. It cannot be predicted on what criterion you will be singled out for termination, purportedly to 'save the planet.'"

Miguel Moreno-Muñoz, a professor of philosophy specializing in ethics, epistemology and technology at the University of Granada, Spain, expressed hope, writing, "Perhaps a more sophisticated culture of privacy will emerge."

Misinformation and mistrust must be addressed for positive internet growth

A number of respondents worried over misinformation, security and other concerns. They said that current issues in internet evolution and what seems to be quite an uncertain future will call for new methods of building trust and security.

Benjamin Kuipers, a professor of computer science at the University of Michigan, wrote, "We will take for granted that there will be AIs that know an enormous amount about each of us, and we will trust them to protect our individual interests, consistent with the ethical requirements of society. One of the great contrasts between the positive and the negative possible futures will be the extent to which we can trust that available knowledge, and to what extent we can trust those AI knowers. In my ideal future, within the next 50 years we will have found ways to ensure trustworthiness in the infrastructure of knowledge and AI knowers. We will understand that there are ethical principles governing the use of knowledge about each of us as individuals, and the respect we must all have for the collected general knowledge that is a resource for humanity. We will trust that those ethical principles will be followed by the vast majority of people, corporations, robots and states, and that there are mechanisms in place to detect violations, protect us from their effects and sanction the violators. The Founding Fathers of the United States of America were among the greatest systems engineers of all time, designing feedback systems, checks and balances to protect our government and our society from the failures of all-too-human leaders, holding power and hungry for more. We need a new generation of great systems engineers, to create new feedback systems to create and maintain a trustworthy society, even with the hugely powerful tools we are creating."

Theodore Gordon, futurist, management consultant and co-founder of the Millennium Project, responded, "We will have Watson-like capabilities for data and analytic reasoning in our pockets. False or suspect news will be rejected or marked with a skull and bones. The internet seems likely to splinter into specialized networks that communicate with each other. Big data will be a given and important in determining epidemics in health and in ideas."

Greg Shannon, chief scientist for the CERT Division at Carnegie Mellon University's Software Engineering Institute, said, "Trust will be a critical social asset. Those communities that value and promote trust will have more life, liberty and happiness. AI and IT will allow communities to ensure varying degrees of security, privacy, resiliency and accountability in building trust. Being trustworthy *all the time* is stressful given that trust is based on competency, dependability, honesty, loyalty, boundaries and sincerity."

A share of respondents discussed the challenges presented by the constant flow of misinformation and by the potential for massive misuses of data.

Thad Hall, a research scientist and coauthor of "Politics for a Connected American Public," wrote, "The ability of the news media to report facts will be hampered by a cascade of alternate news, with different video and audio of the exact same event. Things as simple as what the president said in a meeting will be constantly up for debate as instant, real-time alternate feeds show something different, presenting a different worldview. There will be greater segmentation of the population

and divisions that separate people. People are likely to become more polarized and tribal over the next 50 years. People will be pushed in different directions by advertisers, who will segment us in ways so that people will not even be aware of certain products others use (especially as online sites like Amazon continue to grow greatly). We will receive different news, again exacerbated by the prevalence of fake news that is exceedingly difficult to discern from reality." **Alan Mutter**, a longtime Silicon Valley CEO, cable TV executive and now a teacher of media economics and entrepreneurism at the University of California, Berkeley, said, "I hope internet users in the future will have more control over their data, interactions and the content pushed to them, but I fear that the platform companies – Google, Facebook, Amazon, Baidu and others – will take us in the opposite direction. A safe and satisfying user experience requires far more thought, work and time than the average user can muster. So, we will be at the mercy of the platforms, which have an asymmetrical ability to outwit and outmaneuver any government entities that try to rein them in. The internet will make lives both better and worse in the future. It will provide greater access to information to those who know how to use it well. At the same time, it will push horrific misinformation to people who lack the ability to critically discern what they are seeing, reading or hearing."

Rik Farrow, editor of ";login:" a publication of the USENIX Association, predicted, "The problem of 'fake news' will be solved by news-providers providing digitally signed content, such as photos, recordings and videos, so that news can be trusted."

A professor of psychology for a human-computer interaction institute commented, "It will be more and more difficult to determine the validity of sources of information, and people will have weaker tools to make judgments for themselves. Perhaps I am discouraged by recent political events, but to me they are a harbinger of more to come. We could look to the past: The National Socialists knew all about controlling information."

An online communities researcher said, "We will continue to have problems of community and identity online, where malicious actors quite easily pose as others and manipulate people's opinions."

Security issues will be an ongoing obstacle

Assuring security in a constantly evolving human-technological system was mentioned by respondents as a moving-target challenge that will be a constant in years to come.

Llewellyn Kriel, CEO of TopEditor International, a media services company based in Johannesburg, South Africa, wrote, "Despite all the assurances *security* has become the biggest obstacle in the path of all forms of technology. We predicted this 10 years ago, but things have become worse than even we imagined. The Internet of Things will aggravate this many times. AI so

far shows no signs of being able to address security – personal, corporate and national. We see this situation simply getting worse as criminal cartels, international terrorists and rogue governments exploit the thousands of loopholes."

A professor of computing and digital media expert in in artificial intelligence and social computing predicted, "In 50 years we will have at least one large-scale internet-enabled attack against an entire country, lasting more than five days: power grids, banking, transportation, utilities. People will die. This will (at last) trigger a complete rethinking of the internet protocols, and they will be redesigned with security by design. It will become illegal to use nonconforming devices."

Eugene H. Spafford, internet pioneer and professor of computing sciences at Purdue University, founder and executive director emeritus of the Center for Education and Research in Information Assurance and Security, commented, "Crime and propaganda are going to be even bigger problems, as we have no good, global solutions to deploy as of yet. We need to come to some form of consensus on issues such as fact, primary sources and reliability of information. I see a future where there are more likely to be editorial and content controls, and continued Balkanization of the internet."

Lou Gross, professor of mathematical ecology and expert in grid computing, spatial optimization and modeling of ecological systems at the University of Tennessee, Knoxville, said, "I see entirely new options for theft and an ongoing battle across linked systems to maintain orderly operations. Because of the linkage of systems this 'warfare' has the potential to be highly destructive, and I see major opportunities for insurance companies to enter the fray and provide services to those willing to pay to allow them to maintain an interfaced-lifestyle while having a measure of safety."

The chief marketing officer for a technology-based company said, "Security and privacy will become a very important and critical subject of discussion as individuals and societies at large realize that the benefits come at a severe cost to these freedoms. The EU is pushing and shaping this agenda with its latest effort for protecting from these technologies via GDPR. We will see how all of these play out. At the moment, key technology platforms do not seem to realize the power and the responsibility. The exchange between the European Union's Guy Verhofstadt and U.S.'s Zuckerberg nailed this exact subject in their recent interaction. But the biggest problem and threat for humanity emanates from our historical insecurity and craving for power. As infrastructure is becoming more dependent on AI and the Internet of Things, so do weapons of mass destruction will become more focused on how to better attack them with digital weapons."

Dan Geer, a respondent who provided no identifying details, commented, "This is a question of the whole being different than the sum of the parts. If one is, as I am, certain that only God is

perfect, then a digitalized world that is ever-more optimized begs the question of optimized to what end, to whose benefit, to which criteria of perfection? As Donald Knuth said, 'Premature optimization is the root of all evil,' and there exist optimizations that are, or soon will be, within our reach yet will be forever premature. When you cannot believe what you hear, cannot believe what you see, cannot believe what you smell, taste or touch, what are you? Soon, my friend, soon."

Climate change, the internet and the future of the human race

Several experts observed that this attempt to divine features of the future digital world is futile if the planet can no longer support life in 2069.

Judith Donath, author of "The Social Machine, Designs for Living Online" and faculty fellow at Harvard University's Berkman-Klein Center for Internet and Society, commented, "Western civilization, pinnacle of individual liberty, has culminated in the reckless and wasteful consumption of the Earth's natural resources: We've polluted the water, paved over the land, cut down the forests, strip-mined the mountains. Confronted with the apocalyptic specter of humaninduced mass extinctions and disastrous climate change, we as a species appear to have chosen to do nothing – to continue on the same path that got us here, buying, burning and birthing as if tomorrow simply did not exist. If we – and the myriad other species we share this planet with – are to survive into the next century, the billions of us humans will need to radically change our behavior. It will take extraordinary measures over the next 50 years to get us to eat less, buy less, reproduce less. I see few signs of us moving in that direction in a serious fashion left to our own devices. But now imagine an artificially intelligent government, programmed to re-balance humans and the natural world as painlessly as possible. Though there would be no privacy from the machine government's ceaseless sensing, it would be a pleasant world. We would enjoy an apparent wealth of choice – the illusion of liberty. In reality, personal agency would be quite minimal, our desires redirected and our behavior shaped by subtle, powerful nudges. It may be the only hope we have left."

Divina Frau-Meigs, UNESCO chair for sustainable digital development, said, "Environmental issues will be the primary problem everybody will want to solve in the next 50 years. There is no planet B."

Hank Dearden, executive director at ForestPlanet Inc., said, "My hope is that the more we explore the cosmos, the more we appreciate our precious and fragile planet, and as such use the Internet of Things to monitor and regulate all manner of metrics: oxygen, carbon dioxide, temperature, biomass (trees), trash levels in the oceans, etc."

Brock Hinzmann, a partner in the Business Futures Network who worked 40 years as a futures researcher at SRI International, said, "I choose to remain optimistic, although I don't expect there

to be one future for everyone on the planet, and I expect there will be plenty of abuse of the technology to limit freedom. It could also be that many other concerns, resulting from climate change, global migration and geopolitical conflict, will overwhelm issues related to technology."

Christine Boese, digital strategies professional, noted that the future development of burgeoning cloud technologies relies upon the electrical grid, commenting, "I believe this brilliant system – the internet – is more robust and persistent than anything else the world has created, barring a worldwide failure of electrical grid infrastructure (which is a real possibility). I am *more* skeptical that humanity will still be around in its present, literate form, to access it! It is carbonbased life forms which endanger the future networked and communicating computer. I have high hopes for blockchain technology, to be used for far more than cryptocurrency. I believe evolving XML schemas will continue to add important logic to our metadata for semantic parsing and sense-making. Aggregated data has promise, but the server farms required to support constant crawling, indexing and processing will require outsize electrical grid support, and human civilization's declining literacy, its lack of ongoing infrastructure maintenance and disproportionate grid power draws by server farms could endanger the entire system within 50 years. We are becoming dumb, violent Eloi, without our engineering Morlocks."

Thomas Streeter, a professor of sociology at the University of Vermont, said, "The next 50 years will be shaped by human social and political choices in the context of limited global resources. Whether life in 50 years is better or worse (and for whom) will not be determined by technology."

The founder of a technology research firm wrote, "I always recommend 'He, She, It' by Marge Piercy for an understanding of where the internet could go, and she wrote it before the internet existed. I think cars won't be the same and fully expect that we won't be riding individual cars in 50 years. If we are still functioning as a planet and all this has to be contextualized within dramatic climate change as well as population increase and the resulting migrations flows, with their concomitant political disruptions. Digital life will leave more people behind as it is created for young people by young people, and in an aging planet, this will not serve us well."

A British-American computer scientist commented, "I don't think society in a recognizable form will survive climate change, increasing inequality and the centralization of essential systems to 2069. Increasing centralization of essential systems will reduce society's resilience in the face of these problems, leading to societal collapse."

An anonymous respondent commented, "It depends on what the overall state of the world will be then and whether one subscribes to the mantra of continuing progress. Those of us who take climate change seriously and see the continuing failures to deal with it must see the possibility of some very nasty changes, even down to the mass movement of populations and the contraction of

natural resources including landmasses. In this vision of the future, fixed infrastructure may be a casualty and the local generation of electricity may be the difference between survival and not. One hopes that this pessimism will turn out to be unfounded but at the same time this sort of economic decline or even collapse cannot be ruled out and its impact on technology will be profound. Ad hoc networks might become the main game in town for example."

An anonymous respondent said, "Global climate change will continue unabated as long as ignorance and capitalists are allowed to triumph over humanity."

An anonymous respondent commented, "Climate change is going to have a very destabilizing effect on economies and societies worldwide, so it's difficult to predict how long we will have the infrastructure to support rapid technological advances."

About this canvassing of experts

The expert predictions reported here about the impact of the internet over the next 50 years came in response to questions asked by Pew Research Center and Elon University's Imagining the Internet Center in an online canvassing conducted between July 4, 2018, and Aug. 6, 2018. This is the 10th Future of the Internet study the two organizations have conducted together. Nearly 10,000 experts and members of the interested public were invited to share their opinions on two big-picture questions: 1) the likely future of artificial intelligence and humans, and 2) the ARPANET/internet's 50th anniversary. The first report, "Artificial Intelligence and the Future of Humans," was published Dec. 10, 2018. This second report is an analysis of 530 respondents' answers to questions related to the 50th anniversary of the ARPANET/internet.

The results published here come from a nonscientific canvassing. They cover respondents' answers to these questions:

> *The year 2019 will mark the 50th anniversary of the first host-to-host internet connection. Please think about the next 50 years. Where will the internet and digital life be a half century from now? Please tell us how you think connected technology, platforms and applications will be integrated into people's lives. You can tackle any dimension of this question that matters to you. You might consider focusing on questions like this: What changes do you expect to see in the digital world's platform companies? What changes do you expect to see in the apps and features that will ride on the internet? How will digital tools be integrated into everyday life? What will be entirely new? What will evolve and be recognizable from today's internet? What new rules, laws or innovations in its engineering over the intervening years will change the character of today's internet?*

Participants were further asked:

> *Considering what you just wrote about your expectations for the next 50 years, how will individuals' lives be affected by the changes you foresee?*
>
> *In the next 50 years, technological change (Please choose only one answer):*
> *… will not produce significant change in individuals' lives.*
>
> *… will produce significant change that is mostly for the better for individuals' lives.*
>
> *… will produce significant change that is mostly for the worse for individuals' lives.*

Explain your answer and describe the ways you see changes in digital life influencing individuals in the next 50 years.

The answers of the 530 total responses to this question showed the following:

- 72% said technological change will produce significant change that is mostly for the better
- 25% said technological change will produce significant change that is mostly for the worse
- 3% said technological change will not produce significant change in individuals' lives

An additional 42 respondents (7% of the total number of survey participants) declined to specify if technological change would lead to significant change for the better or worse but did provide longform responses to describe the ways they expect digital life to influence individuals in the next 50 years.

The web-based instrument was first sent directly to a list of targeted experts identified and accumulated by Pew Research Center and Elon University during previous "Future of the Internet" studies, as well as those identified in an earlier study of people who made predictions about the likely future of the internet between 1990 to 1995. Additional experts with proven interest in this particular research topic were also added to the list. Among those invited were researchers, developers and business leaders from leading global organizations, including Oxford, Cambridge, MIT, Stanford and Carnegie Mellon universities; Google, Microsoft, Facebook, Amazon, Kernel, Kyndi, BT and Cloudflare; inductees to the Internet Hall of Fame, most of whom played key roles in the invention and diffusion of the internet; leaders active in global internet governance and internet research activities, such as the Internet Engineering Task Force (IETF), Internet Corporation for Assigned Names and Numbers (ICANN), Internet Society (ISOC), International Telecommunications Union (ITU), Association of Internet Researchers (AoIR), and the Organization for Economic Cooperation and Development (OECD). We also invited a large number of professionals and policy people from technology businesses; government, including the National Science Foundation, Federal Communications Commission and European Union; think tanks and interest networks (for instance, those that include professionals and academics in anthropology, sociology, psychology, law, political science and communications); globally located people working with communications technologies in government positions; technologists and innovators; top universities' engineering/computer science and business/entrepreneurship faculty, graduate students and postgraduate researchers; plus many who are active in civil society organizations such as Association for Progressive Communications (APC), Electronic Privacy Information Center (EPIC) and Access Now; and those affiliated with newly emerging nonprofits and other research units examining the impacts of digital life. Invitees were encouraged to share

the survey link with others they believed would have an interest in participating, thus there may have been somewhat of a "snowball" effect as some invitees invited others to weigh in.

Since the data are based on a nonrandom sample, the results are not projectable to any population other than the individuals expressing their points of view in this sample.

> *The respondents' remarks reflect their personal positions and are not the positions of their employers; the descriptions of their leadership roles help identify their background and the locus of their expertise.*

About a third of the expert respondents elected to remain anonymous. Because people's level of expertise is an important element of their participation in the conversation, anonymous respondents were given the opportunity to share a description of their internet expertise or background, and this was noted where relevant in this report.

In the canvassing of experts, in which Pew Research Center and Elon's Imagining the Internet Center asked about AI and the future of humans and asked questions tied to the internet's 50th Anniversary, 519 respondents overall answered the demographic questions. About 70% identified themselves as being based in North America, while 30% hail from other corners of the world. When asked about their "primary area of internet interest," 33% identified themselves as professor/teacher; 17% as research scientists; 13% as futurists or consultants; 8% as technology developers or administrators; 5% as entrepreneurs or business leaders; 5% as advocates or activist users; 4% as pioneers or originators; 1% as legislators, politicians or lawyers; and an additional 13% specified their primary area of interest as "other."

Following are two lists noting a selection of the key respondents in this canvassing.

Internet Hall of Fame members who participated include: **Leonard Kleinrock**, co-director of the first host-to-host online connection, professor of computer science, University of California, Los Angeles; **Vint Cerf**, co-inventor of the Internet Protocol, now vice president and chief internet evangelist at Google; **Steve Crocker**, a co-initiator of many of the processes and organizations that gave the internet its start, now CEO and co-founder of Shinkuro Inc.; **Dai Davies**, European internet pioneer, a founder of EuropaNet; **Elizabeth Feinler**, the original manager of the ARPANET Network Information Center; **Shigeki Goto,** Asia-Pacific internet pioneer; **Teus Hagen**, Netherlands internet pioneer, former chair and director of NLnet; **Bob Metcalfe**, co-inventor of Ethernet, founder of 3Com, now professor of innovation and entrepreneurship at the University of Texas, Austin; **Craig Partridge**, chief scientist at Raytheon BBN Technologies for 35 years, now chair of the department of computer science at Colorado State University; **Lawrence Roberts**, chief scientist, designer and manager of ARPANET and founder

of five startups (Dr. Roberts passed away in December 2018); **Michael M. Roberts**, first president and CEO of ICANN; **Henning Schulzrinne**, Internet Hall of Fame member, co-chair of the Internet Technical Committee of the IEEE and professor at Columbia University; **Paul Vixie**, best known for designing and implementing major Domain Name System protocol extensions and applications; and several additional Hall of Famers who responded anonymously.

Additional key respondents:

Walid Al-Saqaf, senior lecturer at Sodertorn University, Sweden, and member of the board of trustees of the Internet Society (ISOC); **Aneesh Aneesh**, author of "Global Labor: Algocratic Modes of Organization"; **Kostas Alexandridis**, author of "Exploring Complex Dynamics in Multi-agent-based Intelligent Systems"; **Micah Altman**, director of research and head scientist for the program on information science at MIT; **Geoff Arnold**, chief technology officer for the Verizon Smart Communities organization; **Henry E. Brady**, dean, Goldman School of Public Policy, University of California, Berkeley; **David Bray**, executive director for the People-Centered Internet coalition; **Erik Brynjolfsson**, director of the MIT Initiative on the Digital Economy and author of "Machine, Platform, Crowd: Harnessing Our Digital Future"; **Jamais Cascio**, distinguished fellow at the Institute for the Future; **Barry Chudakov**, founder and principal at Sertain Research and StreamFuzion Corp.; **Joël Colloc**, professor at Université du Havre Normandy University and author of "Ethics of Autonomous Information Systems"; **Kenneth Cukier**, author and senior editor at The Economist; **Eileen Donahoe**, executive director of the Global Digital Policy Incubator at Stanford University; **Judith Donath**, Harvard University's Berkman Klein Center for Internet & Society; **William Dutton**, Oxford Martin Fellow at the Global Cyber Security Capacity Centre; **Susan Etlinger**, an industry analyst for Altimeter Group; **Jean-Daniel Fekete**, researcher in information visualization, visual analytics and humancomputer interaction at INRIA, France; **Seth Finkelstein**, consulting programmer and EFF Pioneer Award winner; **Charlie Firestone**, executive director and vice president of the Aspen Institute's communications and society program; **Bob Frankston,** internet pioneer and software innovator; **Divina Frau-Meigs**, UNESCO chair for sustainable digital development; **Richard Forno**, of the Center for Cybersecurity at the University of Maryland, Baltimore County; **Oscar Gandy**, professor emeritus of communication at the University of Pennsylvania; **Ashok Goel**, director of the Human-Centered Computing Ph.D. Program at Georgia Tech; **Ken Goldberg**, distinguished chair in engineering, director of AUTOLAB and CITRIS at the University of California, Berkeley; **Marina Gorbis**, executive director of the Institute for the Future; **Theodore Gordon**, futurist and co-founder of the Millennium Project; **Kenneth Grady**, futurist, founding author of The Algorithmic Society blog and adjunct and adviser at the Michigan State University College of Law; **Sam Gregory**, director of WITNESS and digital human rights activist; **Wendy Hall**, professor of computer science at the University of Southampton, UK, and executive director of the Web Science Institute; **Perry Hewitt**, a marketing, content and

technology executive; **Brock Hinzmann**, a partner in the Business Futures Network who worked for 40 years as a futures researcher at SRI International; **Bernie Hogan**, senior research fellow, Oxford Internet Institute; **Jeff Jarvis**, director of the Tow-Knight Center at City University of New York's Craig Newmark School of Journalism; **Bryan Johnson**, founder and CEO of Kernel (developer of advanced neural interfaces) and OS Fund; **Frank Kaufmann**, president of Filial Projects and founder and director of the Values in Knowledge Foundation; **Andreas Kirsch**, fellow at Newspeak House, formerly with Google and DeepMind in Zurich and London; **Michael Kleeman**, a senior fellow at the University of California, San Diego, and board member at the Institute for the Future; **Bart Knijnenburg**, assistant professor of computer science active in the Human Factors Institute at Clemson University; **Gary L. Kreps**, distinguished professor and director of the Center for Health and Risk Communication at George Mason University; **Larry Lannom**, internet pioneer and vice president at the Corporation for National Research Initiatives (CNRI); **Peter Levine**, associate dean for research and Lincoln Filene Professor of Citizenship & Public Affairs in Tufts University's Jonathan Tisch College of Civic Life; **John Markoff**, fellow at the Center for Advanced Study in Behavioral Sciences at Stanford University and author of "Machines of Loving Grace: The Quest for Common Ground Between Humans and Robots"; **Matt Mason**, roboticist and former director of the Robotics Institute at Carnegie Mellon University; **Craig J. Mathias**, principal for the Farpoint Group; **Jerry Michalski**, founder of the Relationship Economy eXpedition (REX); **Steven Miller**, vice provost and professor of information systems at Singapore Management University; **Monica Murero**, director of the ELife International Institute and associate professor in sociology of new technology at the University of Naples Federico II, Italy; **Grace Mutung'u**, co-leader of the Kenya ICT Action Network; **Ian Peter**, pioneer internet activist and internet rights advocate; **Justin Reich**, executive director of the MIT Teaching Systems Lab; **Peter Reiner**, professor and co-founder of the National Core for Neuroethics at the University of British Columbia; **Marc Rotenberg**, director of a major digital civil rights organization; **Douglas Rushkoff**, writer, documentarian, and professor of media at City University of New York; **David Sarokin**, author of "Missed Information: Better Information for Building a Wealthier, More Sustainable Future"; **Ben Shneiderman**, distinguished professor and founder of the Human Computer Interaction Lab at the University of Maryland; **Dan Schultz**, senior creative technologist at Internet Archive; **Evan Selinger**, professor of philosophy at Rochester Institute of Technology; **Greg Shannon**, chief scientist for the CERT Division at Carnegie Mellon University's Software Engineering Institute; **Daniel Siewiorek**, professor with the Human-Computer Interaction Institute at Carnegie Mellon University; **Mark Surman**, executive director of the Mozilla Foundation and author of "Commonspace: Beyond Virtual Community"; **Brad Templeton**, chair for computing at Singularity University, software architect and former president of the Electronic Frontier Foundation; **Baratunde Thurston**, futurist, former director of digital at The Onion and cofounder of the comedy/technology startup Cultivated Wit; **Stuart A. Umpleby**, professor and director of the research program in social and organizational learning at George Washington

University; **Michael Veale**, co-author of "Fairness and Accountability Designs Needs for Algorithmic Support in High-Stakes Public Sector Decision-Making"; **Amy Webb**, founder of the Future Today Institute and professor of strategic foresight at New York University; **David Wells**, chief financial officer at Netflix; **Betsy Williams**, researcher at the Center for Digital Society and Data Studies at the University of Arizona; **John Willinsky**, professor and director of the Public Knowledge Project at Stanford Graduate School of Education; **Yvette Wohn**, director of the Social Interaction Lab at the New Jersey Institute of Technology and expert on human-computer interaction; **Cliff Zukin**, professor of public policy and political science at the School for Planning and Public Policy and the Eagleton Institute of Politics, Rutgers University

A selection of institutions at which some of the respondents work or have affiliations:

Abt Associates; Access Now; Aeon; Allen Institute for Artificial Intelligence; Alpine Technology Group; Altimeter Group; American Institute for Behavioral Research and Technology; American Library Association; Antelope Consulting; Anticipatory Futures Group; Arizona State University; Artificial Intelligence Research Institute, Universitat Autònoma de Barcelona; Aspen Institute; AT&T; Australian National University; Bad Idea Factory; Bar-Ilan University, Israel; Bloomberg Businessweek; Bogazici University, Turkey; Brookings Institution; BT Group; Business Futures Network; California Institute of Technology; Carnegie Mellon University; Center for Advanced Study in the Behavioral Sciences, Stanford University; Centre for Policy Modelling, Manchester Metropolitan University; Centre National de la Recherche Scientifique, France; Cisco Systems; Clemson University; Cloudflare; Columbia University; Comcast; Constellation Research; Cornell University; Corporation for National Research Initiatives; Council of Europe; Agency for Electronic Government and Information Society in Uruguay; Electronic Frontiers Australia; Electronic Frontier Foundation; Emergent Research; ENIAC Programmers Project; Eurac Research, Italy; FSA Technologies; Farpoint Group; Foresight Alliance; Future of Privacy Forum; Future Today Institute; Futurism.com; Gartner; General Electric; Georgia Tech; Ginkgo Bioworks; Global Forum for Media Development; Google; Harvard University; Hokkaido University, Japan; IBM; Internet Corporation for Assigned Names and Numbers (ICANN); Ignite Social Media; Information Technology and Innovation Foundation; Institute for Defense Analyses; Institute for the Future; Instituto Superior Técnico, Portugal; Institute for Ethics and Emerging Technologies; Internet Engineering Task Force (IETF); International Academy for Systems and Cybernetic Sciences; Internet Society; Institute for Communication & Leadership, Lucerne, Switzerland; Jet Propulsion Lab; Johns Hopkins University; Kansai University, Japan; Institute for Systems and Robotics, University of Lisbon; Institute of Electrical and Electronics Engineers (IEEE); Keio University, Japan; Kernel; Kyndi; Knowledge and Digital Culture Foundation, Mexico; KPMG; Leading Futurists; LeTourneau University; The Linux Foundation; Los Alamos National Laboratory; Machine Intelligence Research Institute; Massachusetts Institute of Technology;

Maverick Technologies; McKinsey & Company; Media Psychology Research Center; Microsoft; Millennium Project; Monster Worldwide; Mozilla; Nanyang Technological University, Singapore; National Chengchi University, Taiwan; National Institute of Mental Health; NetLab; The New School; New York University; Netflix; NLnet Foundation; NORC at the University of Chicago; Novartis, Switzerland; Organization for Economic Cooperation and Development; Ontario College of Art and Design Strategic Foresight and Innovation; Open the Future; Open University of Israel; Oracle; O'Reilly Media; Global Cyber Security Capacity Center, Oxford University; Oxford Internet Institute; Packet Clearing House; People-Centered Internet; Perimeter Institute for Theoretical Physics; Politecnico di Milano; Princeton University; Privacy International; Purdue University; Queen Mary University of London; Quinnovation; RAND; Research ICT Africa; Rochester Institute of Technology; Rose-Hulman Institute of Technology; Russell Sage Foundation; Salesforce; SRI International; Sciteb, London; Shinkuro; Significance Systems; Singapore Management University; Sir Syed University of Engineering and Technology, Pakistan; SLAC National Accelerator Laboratory; Södertörn University, Sweden; Social Science Research Council; University of Paris III: Sorbonne Nouvelle; South China University of Technology; Stanford University; Straits Knowledge; Team Human; The Logic; Technische Universität Kaiserslautern, Germany; Tecnológico de Monterrey, Mexico; The Crucible; United Nations; University of California, Berkeley; University of California, Los Angeles; University of California, San Diego; University College London; University of Denver Pardee Center for International Futures; Universitat Oberta de Catalunya; Universidade NOVA de Lisboa, Portugal; the Universities of Alabama, Arizona, Delaware, Florida, Maryland, Michigan, Minnesota, Pennsylvania, Southern California, Utah and Vermont; the Universities of Calcutta, Cambridge, Cologne, Cyprus, Edinburgh, Granada, Groningen, Liverpool, Otago, Pavia, Salford and Waterloo; UNESCO; USENIX Association; U.S. Department of Energy; U.S. Naval Postgraduate School; U.S. Special Operations Command SOFWERX; Telecommunications and Radiocommunications Regulator of Vanuatu; Virginia Tech; Vision & Logic; Vizalytics; World Wide Web Foundation; Wellville; Wikimedia; Witness; Yale Law School Information Society Project. Complete sets of credited and anonymous responses can be found here:

https://www.elon.edu/u/imagining/surveys/x-2-internet-50th-2019/credit/

https://www.elon.edu/u/imagining/surveys/x-2-internet-50th-2019/anonymous/

Acknowledgments

We are extremely thankful for the contributions of the people who participated in this canvassing.

This report is a collaborative effort based on the input and analysis of the following individuals.

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