Introduction
Scenario Methodology

What potential innovations could IEEE foster over the next two decades that would most benefit humankind? To answer that question, one must first understand the evolving context within which IEEE operates, the range of innovations now emerging, and the uncertainties upon which the ultimate outcomes will depend.

This report invites readers on an exploration of key trends and uncertainties shaping IEEE’s operating environment in order to identify the actions that IEEE leaders should take today to assure the organization’s success and relevance across a range of alternative futures. These alternative futures can best be described in scenarios that stretch thinking out to the year 2030, so that the decisions made in the near term reflect a larger opportunity space than would otherwise be visible. With these scenarios in mind, IEEE is in a better position to identify strategies that align with its vision, and then to translate these strategies into operational imperatives. This approach will help leaders ensure that their thinking focuses on the highest-potential innovations in the larger world of technology as well as within IEEE over the next two decades.

To this purpose, IEEE engaged the Institute for Alternative Futures (IAF) to develop a set of four alternative scenarios, i.e., stories describing how the future may unfold in different ways. When developing scenarios of the future, it is useful to apply two different lenses. An objective lens defines the probability space in which the future will unfold and helps assess plausibility and likelihood for the range of imagined outcomes. A subjective lens articulates the shared hopes and fears that we often project—consciously or unconsciously—onto the future. Neither lens is sufficient without the other. When a group uses only one of these lenses, the future becomes either an intellectual exercise devoid of meaning, or a playful fantasy devoid of import. However, by applying these two lenses jointly, people can identify meaningful images of surprising success that illuminate strategic insights and invite concerted action. These two lenses combine in IAF’s unique “aspirational futures” approach to scenario development.

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The “aspirational futures” approach (see Figure 1) describes three “zones” of the future. These zones are bounded by plausibility (the objective lens) and differentiated by preferability (the subjective lens):

- A “zone of conventional expectation,” reflecting the extrapolation of known trends—the expectable future;
- A “zone of growing desperation” which presents a set of plausible challenges that may emerge—a challenging future; and
- A “zone of high aspiration” in which stakeholders pursue visionary strategies and achieve surprising success—an aspirational future.

Figure 1. IAF’s “Aspirational Futures” Approach

The IAF team began developing this report by conducting futures research on 18 drivers of change specific to IEEE’s macro and operational environment. Through an online survey, IEEE then selected nine of these drivers to form the basis of scenario development. The nine drivers are: Global Intelligent Networks; Knowledge Creation and Dissemination; Workforce; Scientific Disciplines; Intellectual Property; Technologies and Generations; Standards; Conferences; and Energy. IAF then developed forecasts in the expectable zone for each of these nine drivers.
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In the next phase of the project, IAF conducted interviews with four members of IEEE's Board of Directors in order to refine the expectable forecasts and to learn about the interviewees' fears and aspirations with respect to IEEE's future. These nine expectable forecasts served as a baseline for a scenario-building workshop which IAF designed and conducted in October 2013. Participants to this workshop were members of the IEEE Ad Hoc Committee on Strategic Planning. During the first part of this workshop, participants outlined two alternative forecasts for each driver—that is, one “challenging” and one “aspirational”—as a complement to the “expectable” forecasts provided before the workshop. Participants also explored further the zone of higher aspiration. This exploration of alternative futures informed, in the second phase of the workshop, the creation of a list of key strategic questions for IEEE to consider in the near term. The participants then ranked the strategic questions in terms of importance and urgency.

In the final phase of the project, IAF developed the narratives of four scenarios that can be summarized as follows:

• **Scenario 1: Smart Technologies, Missed Opportunities**
  
  **Expectable Zone**
  The combination of big data and social networks creates high-quality knowledge technologies and networks around the world. However, leaders and communities fail to use them to address the grand challenges of the 21st century.

• **Scenario 2: Info, Info Everywhere (and Not a Drop to Drink)**
  
  **Challenging Zone**
  A small number of powerful entities create and control advanced analytics that turn information into knowledge. Most people lack access to these sophisticated tools for making sense of the ever-increasing reams of information.

• **Scenario 3: An Integrated Knowledge Network**
  
  **Aspirational Zone**
  Visionary leaders facilitate the creation of a highly integrated global knowledge network that is accessible to all. The network combines advanced analytics and human expertise to create high-quality knowledge, and increasingly wisdom, for alleviating global challenges.

• **Scenario 4: Distributed Talent for Good**
  
  **Aspirational Zone**
  Rising unemployment and shifts in societal expectations undermine traditional organizational structures, pushing most associations and many other organizations to the brink of extinction. However, a handful of these associations reinvent themselves as networks of autonomous entities united by a common purpose.

How to Read This Report

The first part of this report contains the four scenario narratives. After reading each scenario, ask yourself the following questions:

- What are the key changes in this scenario that have significant implications for IEEE?
- What opportunities and challenges does IEEE need to address to be most successful in that scenario?
- What actions taken now would be relevant no matter the scenario?
- What actions do the alternative scenarios suggest can be taken now with the largest payoffs in the future?

In the second part, a matrix allows for side-by-side comparison of the scenarios along the nine drivers mentioned above. Vertically, the matrix shows the breadth of factors that must be considered as a coherent whole when thinking about the futures described by the scenarios. Horizontally, the matrix shows the differences in each factor across the four scenarios. Many readers will likely find this matrix useful as they try to differentiate the scenarios in their own minds.
Scenario 1 – Smart Technologies, Missed Opportunities
Expectable Zone

The years leading to 2030 witnessed significant technological change affecting all areas of human life. One of the largest impacts was the fact that many knowledge technologies gave users an opportunity to master information and data. These smart technologies allowed knowledge to be tailored to individual users. However, by 2030, only the wealthier and more educated can navigate the many gates and barriers that restrict access to the highest-quality knowledge shaping 21st century life. Governance models have failed to capitalize on these technologies for transformative and lasting positive change, thus neglecting to address major challenges that affected humanity in the 2010s.

Throughout the 2010s and 2020s, communication flows between people around the world increased significantly through virtual platforms such as social networks. In parallel, intelligent technological devices that used cognitive computing aided by biosensors, bionanosensors, or chemical and biochemical nanosensors became ubiquitous. This created reams of real-time information everywhere in the world flowing from social media, sensors and monitors, government databases, and other online sources. Advanced analytics became more effective at collecting and mining these huge datasets, providing answers that informed decisions like never before. These systems even increasingly offered a predictive capacity by combining multiple real-time data flows. In the 2010s many people expressed great hopes that these nascent intelligent global networks blending human and artificial knowledge could solve the grand challenges of our time.

Social media and content aggregators increasingly merged into intelligent platforms tailored to the needs of specific communities of interest, as well as to each user's learning style and context. For fast-moving events, these platforms were used to find patterns in information that had previously gone unnoticed. In cases where in-depth knowledge was required, these aggregators quickly identified the highest-quality expert opinions from human and/or machine sources. To ensure ongoing learning, they also supplemented raw content with tools, such as digital badges, i.e. online rewards indicating a student's achievements and showcasing them to her community. More and more knowledge content, including highly detailed technical and scientific knowledge, incorporated multimedia components such as hyperlinks, videos, interactive maps, infographics, and learning games. Although text has not disappeared in 2030, for the younger generations reading as a mode of learning has lost considerable ground relative to more interactive media. Technical and scientific content was also delivered in smaller packages in response to "content-hopping" by users.

The rapid pace of change and the fast acceptance of new technologies around the world stimulated the demand for international technical standards that could guarantee worldwide interoperability and safety, particularly for the infrastructure of information and communication technologies (ICT). Cooperation among standards developing organizations (SDOs) worldwide improved, although for those technologies that did not fit clearly into one established sector (e.g., electric cars, nanotechnologies, or additive manufacturing), some SDOs competed to institute their standards as the best practice. Established SDOs also faced mounting challenges, such as file-sharing among users and the growing movement of industry consortia, spearheaded in the 2010s by the Organization for the Advancement of Structured Information Standards (OASIS) and the World Wide Web Consortium (W3C). These industry consortia opened standards-setting to all interested members in the private, public, and civil society sectors. To face these challenges, SDOs experimented with new processes and business models, such as tailored curation services and bundled packages of cross-industry standards.

The promise of accessing tailored and data-fed knowledge heightened the demand for open access to online content. This spawned new business models that allowed users to feed into their content aggregators for free, including author-paying models like PLOS, Springer, and Hindawi. Knowledge generation and supervision also became more distributed, thus challenging traditional approaches to publishing copyrights. Community reviews, which many recognized as faster and more transparent than peer reviews, gained traction. More scientific and technical research and publications became "crowd-sourced" or even "open source" (see Box 1), thanks to collaborative platforms and projects, such as GalaxyZoo, SETI@home and Folding@home in the 2010s, which enabled academics to delegate specific tasks and submit problems to the crowd. As the platforms offering these new models attracted more and more users, publication revenues for longstanding publishing houses, academic journals, and associations continued to decline steadily. These organizations gradually lost

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1 Content-hopping is used here to describe the practice of looking briefly at parts of different content sources, for example articles or videos, instead of reading or watching one or all in their entirety.
**Scenario 1 – Smart Technologies, Missed Opportunities**

Expectable Zone

their role as gatekeepers of information and credibility. By 2030, only two of the journals boasting high impact factors\(^1\) in 2013—The New England Journal of Medicine and Nature—have survived with essentially the same peer-review, reader-paying business model that they used in the past.

The conference business also faced mounting threats during those years. Slow recovery from the global economic recession that started in the late 2000s fueled concerns about the return on investment of attending conferences. As a result, the patience of conference audiences for low-quality sessions declined considerably. Attendees expected conferences to provide tailored learning experiences and meaningful connections to others in their field. By the late 2010s, conference organizers deployed networking tools that scanned social data to collect detailed information on participants’ interests and expectations. These networking tools then created meeting opportunities for people with shared interests. Many speakers used interactive data visualization displays to deliver highly technical content. More and more conferences became invitation-only, with higher fees covering the costs of a better conference experience. Attendee feedback was increasingly measured and monitored, for example, through social networks enabling participants to rate speakers in real time. This way, low-quality presenters could be screened out.

The nature of work itself saw significant changes during the 2010s and 2020s. Machines increasingly took on activities previously performed by humans. Robots with enhanced senses and dexterity could perform rote tasks, while intelligent machines usurped many of the roles previously played by experts. In the 2010s, this caused large increases in global unemployment, while education systems struggled to prepare the next generation for the new world of work. The poorest communities remained those which suffered most from both unemployment and insufficient education outcomes.

However, by the 2020s, a new form of more flexible work began to replace formal employment. Instead of relying on a pool of permanent employees, organizations increasingly contracted out tasks as needed, reducing their fixed labor costs and increasing their ability to respond to sudden changes in the marketplace. Educated and tech-savvy workers maintained loose affiliations with several institutions, finding and completing tasks remotely through online crowd labor pools and employer-freelancer matchmaking platforms. As a result, traditional companies—with the exception of some large successful multinationals which continued to draw in gifted employees—struggled to offer the workplace flexibility, democracy, and culture required to attract the best talent.

Subject matter expertise remained vital, especially in science and technology. However, the most promising new knowledge areas, such as nanobiotechnology, 3D organ printing, and quantum computing, often came not from the established disciplines but from the space between them. As a result, scientific and technical experts had to develop new skills for collaboration, which drew upon social sciences. Demand grew for “bridgers” or “synthetists,” as well as for “T-shaped” experts—that is, those who have deep expertise in one or more disciplines but are conversant across a range of others. While traditional academic institutions adapted slowly to meet this demand, online courses quickly incorporated these new skills into their curricula. The early experiments of the 2010s, including Academia.edu, ResearchGate, and Mendeley, evolved into platforms for collaborative research discovery, content-sharing, and cooperation. Many, like PLOS, intentionally removed specific scientific categorizations in order to foster cross-disciplinary research. Organizations that continued to run into the walls of their own disciplines saw their influence and competitiveness decline.

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1. Journal impact factors are published annually in the Journal Citation Reports (JCR). The impact factor of an academic journal measures the average number of times that articles published in this journal in the past two years have been cited in the JCR year.
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Yet around the world, many people in poor communities did not have access to the advanced IT infrastructure required to take advantage of the high-quality knowledge and new working modalities of the 21st century. Differentials of power over knowledge effectively cut large segments of the global population off from the benefits offered by the knowledge systems. The governments and corporations which owned major portions of the infrastructure underlying the intelligent global networks had few incentives to extend access to these networks to the most disadvantaged communities. Moreover, incumbent corporations sought to expand their control over networks by acquiring companies that offered disruptive innovations, or by setting new restrictions on Internet traffic, search algorithms, and communication tools. Therefore, in a context where 20th century formal employment was quickly disappearing, technologically disadvantaged people had nowhere to turn to make a living.

In addition, growing challenges in the global intellectual property (IP) system limited the overall level of innovation. In some sectors and some regions, well-protected IP rights provided organizations with the economic incentive to produce and sell innovative products in global and national markets. However, for other companies, enforcement of these rights became difficult and unprofitable. In a global market of goods and services, many players did not respect these protections. Following the shift from “first-to-invent” to “first-to-file” via the 2011 America Invents Act, patent trolling\(^3\) intensified. These trends raised the number, cost, intensity, and public awareness of IP-related lawsuits. Many governments initiated reforms of their IP systems, but critical bottlenecks and enforcement issues failed to be addressed at the global level.

By 2030, the promise of global intelligent systems to help solve grand challenges has not been met. While these systems were able to answer many questions that humans had asked in the past, their utility was constrained by humans’ inability to ask the right questions for the future. These systems proved unable to anticipate major disruptions and non-linear changes. In addition, political and corporate will remained insufficient to take groundbreaking scientific discoveries to scale, particularly in the energy sector. In 2030, despite worldwide advocacy for large-scale adoption of alternative energy sources, fossil fuels remain the dominant energy sources. Poverty and inequality levels have stagnated in most parts of the world and worsened in others. Concentration of data storage points in the hands of a few large organizations heightened long-held fears about cyber security breaches, and increased vulnerability to weather-related outages such as those caused by Hurricane Imelda in 2022 that affected millions of people.

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\(^3\) Filing for patents on vague ideas not actually brought to market in order to collect licensing fees for subsequent inventions that could be seen as violating the earlier patent.
Scenario 2 – Info, Info Everywhere (and Not a Drop to Drink)
Challenging Zone

Looking back at the 2010s, people in 2030 argue which was the bigger surprise—was it the collapse of economies, energy grids and governments, or the speed of the collapse itself that was most surprising? The optimistic position that technological wonders would drive humanity toward a better 21st century turned from questionable to laughable. Over the two decades leading to 2030, the vast majority of people remained mired in the Information Age, while a small number of corporations and government entities made it into the Knowledge Age. A continuously growing volume of information—that is, collections of facts as data—still overwhelms most people in 2030. On the other hand, those organizations that provide knowledge—that is, the placement of information into a context that supports learning and decision-making—are doing very well.

Throughout the 2010s, a greater proportion of human life and interaction moved online, creating petabytes of data in 2014, zettabytes in 2025, and yottabytes in 2030. The scale of this data generation, dubbed “big data,” launched a gold rush as corporations, governments, and entrepreneurs sought a more robust and more granular understanding of people’s behaviors and preferences. Similarly, philanthropies, nonprofits, and social service agencies developed community maps that helped them target their resources and programs. The greater availability of data prompted two distinct calls for transparency. One was a call for greater openness of the data collected by governments, intergovernmental agencies, and businesses. The other was a call for greater transparency in how the data were being used.

The promise of “big data” seemed so great at the time that one really has to wonder how things might have turned out differently had successive economic recessions in the 2010s not led to massive fiscal cuts. These cuts greatly undermined science, technology, engineering and mathematics (STEM) education, as well as other public sector investments related to “big data.” The cuts therefore slowed the creation of new knowledge, decreasing both the volume and the quality of research in these areas. Moreover, these cuts concentrated valuable expertise in advanced analytics in the hands of those graduating from elite universities. This situation did not improve in the 2020s, which saw a stream of engineering departments closing down in major U.S. universities.

Corporations and surveillance agencies, on the other hand, increased their investments in the advanced analytics required to make sense of “big data.” These organizations restricted their funding to schools that supplied graduates who best served their commercial needs. Paying these graduates extremely well, they set them to work in developing the game-changing knowledge technologies that would convert “big data” to “big profits.” These corporations reaped colossal benefits from data-driven marketing as well as personalized products and services. In many countries, the laws and regulations that governments passed effectively protected and reinforced the power of these corporations as a way to nurture economic growth.

However, in the public’s eye, the “big data” craze had led nowhere. Calls for transparency had only produced longer and longer “terms of use” for online media to which most people agreed and that fewer and fewer people actually read. In the early 2020s, demand for greater transparency receded. Far from regaining ownership over their personal information, the public passively accepted all the “terms of use” offered to them. The tradeoff of giving away personal information in exchange for tailored services and products ultimately went unchallenged. Users perceived transparency as a burden rather than a tool for empowerment.

What these users failed to appreciate was that an intricate web of influential groups was restricting the benefits of “big data” to the most powerful organizations and individuals. A few islands of power shaped and dominated high-quality knowledge networks, using these knowledge networks to gain or maintain power and control. This handful of beneficiaries could not be readily identified, as they interacted through a diffused grid of power links among corporations and governments in rich and poor countries alike.

Most people remained unable to extract and organize valuable intelligence from the overwhelming amount of data that became available to them. For them, knowledge was drowned in a sea of information. While search engines and curation services became much more tailored, only rarely was personalization associated with higher quality information for the consumer. Instead of making knowledge available, these sophisticated technologies pushed low-quality intelligence onto the users, while also driving people away from active, curiosity-driven knowledge gathering. As a result, the public became increasingly disengaged in striving to find or generate knowledge. Meanwhile, a large part of the worldwide population simply did not have access to the infrastructure that could support ever-increasing volumes of information.
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Challenging Zone

After the series of economic recessions of the late 2010s, which were complicated by the massive increase in unemployment as automation replaced human labor, the greater agility and sophistication of the corporations that had entered the Knowledge Age helped produce a stable—though inequitable—footing for economic growth. Some corporations provided truly innovative products, meeting longstanding customer and societal needs. For example, physical security improved almost everywhere as intelligent surveillance systems made criminal activity far less attractive. However, those who controlled access to knowledge kept the lion’s share of this economic growth, leaving the majority of the world’s population growing needier.

Overall, economic and political elites reined in the emergence of solutions to the grand challenges of the 21st century. Innovation was increasingly viewed as a means for the exploitation of the many by the few, rarely occurring in areas that would enhance the human condition. Basic science research leading to unexpected, influential discoveries was increasingly devalued compared to research projects with technological applications for near-immediate implementation for private gain. Important knowledge created by past generations was lost in a pattern of rapid technological change in which innovators were constantly reinventing the wheel with small tweaks for big economic gains.

The clandestine nature of the most profitable knowledge technologies challenged the intellectual property (IP) protections that had long been assumed to undergird economic growth. Repeated failures to reach consensus in negotiations among World Trade Organization members led countries to adopt regional and national IP regulations. By 2020, the global IP system had become a patchwork where competing interests were used to control rather than share knowledge. Some regions had such weak IP laws that the only way to exploit knowledge was through secrecy, as patent pirates could pounce on any publicly exposed innovation with copies coming to market often before the original invention. In other regions, even having strong IP laws was insufficient, as the ineffectiveness of patent offices encouraged patent trolling and discouraged cost-effective methods such as patent pooling and licensing. In those few countries that improved their handling of patents to maintain the competitive advantage of IP, the protections could only be enforced within national borders. This restricted the spread of knowledge beyond patent holders. By 2030, the general aversion to the sharing of knowledge has undermined the value of scientific publications, in-person meetings, conferences, and other venues for exchanging ideas.

Heightened nationalism also caused critiques of the governance model of the global Internet to grow louder in the mid-2020s. Many countries resented the U.S. influence on the technical bodies in charge of overseeing the global telecommunication infrastructure. They also resented the convergence of global data flows onto U.S. territory as an unfair advantage for American firms. Bans on U.S.-based websites (e.g., Facebook) multiplied. By the late 2020s, many countries were using “digital embargoes” for leverage in international negotiations, banning websites from other countries. In Europe, a regional body was created to oversee the Internet in the region, effectively limiting the flow of information coming from North America. By 2030, the global standards system for information and communication technologies has fragmented into regional blocks.

The surveillance data that served corporate and government interests was increasingly collected from DNA databases and from the wearable devices that had become popular in the late 2010s. These wearable devices effectively formed an unbreakable bond holding citizens and consumers in a fixed orbit around surveillance agencies and marketing departments. Ubiquitous surveillance had its benefits, however, like reducing crime and controlling epidemics. By the late 2020s, many were trumpeting the age of “extreme safety.” Nevertheless, these apparent benefits did not engender actual trust of global knowledge networks, as could be seen in data use scandals that resulted in civil unrest and revolts in places around the world. The Center for Brain-Machine Interface Ethics, created in 2021, did very little to improve the general opinion and ethical usage of ubiquitous man-machine devices.

By the 2020s, popularity had surpassed quality as the gauge of relevance for most information-selecting algorithms for end-users. “Like”-based reviews, initially used for rating entertainment products, increasingly replaced peer reviews for scientific and technical publications. The judgment of the majority led to a decline in the quality of scientific and technical publications. This provoked a sharp decline in the quality of research in the 2020s. The decline in volume and quality of scientific research and the distrust of the Internet of Things and of its creators significantly damaged the reputation of research and education in science, technology, engineering and mathematics among the broader public. In 2030, prospective students look more to the arts than to science for meaningful jobs.

By the late 2020s, a severe shortage had developed in the number of people capable of building smart technologies. On the one hand, the engineering profession was reduced to a small elite. Much like professional athletes in the 2010s, stories of expensive “transfers” of
Scenario 2 – Info, Info Everywhere (and Not a Drop to Drink)
Challenging Zone

technical geniuses from one company to another made big news. With little loyalty for companies that did not offer them much meaning, these geniuses were essentially for sale to the highest bidder, and some companies took extreme measures to gain their favors. On the other hand, the general public continued to lack basic familiarity with the technical aspects of their devices, even as computing and hybrid robotics/living organism structures infused nearly all aspects of life. By 2030, the long-term view of sciences advancing humanity has largely been lost, and with it the sense of belonging to a purposeful professional community that many scientists had previously cherished.
In 2030, people around the world can celebrate the great progress made in meeting the global challenges of the 21st century. The networked generation and application of knowledge has informed leaders and communities of both the nature of those challenges and their solutions, producing results that many in 2013 would have viewed as unlikely. For example, one of the most cited successes is the reduction of fossil fuels to less than 20% of the global energy supply.

By the mid-2010s, most parts of the world had been repeatedly hit by severe economic and ecological crises. An already fragile global economic system was further threatened by new technologies—such as robots, 3-D printers, and biomimetic devices—which overturned entire industries that had long depended on human labor. Many blamed the education system for not equipping humans with the creativity and technical skills to address the wicked problems of the times.

However, over the years leading to 2020 many came to recognize that the diffusion of intelligent automated devices was irreversible, and in fact offered great promise. Instead of lamenting the demise of the old system, visionary leaders in multiple sectors advocated for a global network that could both spread knowledge and foster the creation of genuine wisdom. This effort produced a global system that combined social networks and ubiquitous smart devices.

By the mid-2010s, technologies had become highly intuitive and adaptive, tailoring information not only to what people wanted, but also to their learning capacities and contexts. Networks of artificial intelligence asked the right questions of the right people at the right time and place. This new type of advanced knowledge services was first available through mobile device-based aggregators. By the 2020s, however, pervasive wearable or embedded devices had integrated knowledge into everything people did.

As a result, people of different ages and socioeconomic backgrounds were no longer segregated by their technology of choice. The harmonization of technology standards and adoption across national and cultural boundaries allowed for the formation of large, diverse groups with a shared technological identity. This facilitated greater worker mobility across countries, enabling ageing societies in the U.S., Europe, and Asia to draw from labor supplies in countries with younger demographics.

By the late 2010s, new paradigms of hardware and software architecture design had enabled a new generation of hardware infrastructure. Software and hardware became integrated organically to enable the free flow of knowledge and wisdom, culminating in a “global brain” which linked a vast neural network of sensors and devices to massive computational capacities that could make sense of human and machine systems. The brain’s infrastructure optimized the use of energy and rare material resources, reducing ecological impacts. This infrastructure was seamless across geographic boundaries, allowing for local practices and interests to be considered before being fed back to the global network. Anywhere in the world, the performance of the network and its infrastructure was independent of providers and manufacturing origin.

The seamlessness of this “global brain” infrastructure promoted transparency throughout the network, leading to higher levels of accountability for its users. As a result, governance at the global, national, and local levels improved considerably throughout the 2020s. The network became a stabilizing force, as a shared understanding of otherwise contentious situations became readily available. In a sense, the world went from being informed to being knowledgeable, with the opportunity for a growing number of people to become wise.

As shared knowledge engendered trust, people were able to let go of past conflicts and personal agendas to embrace an emerging global ethic that emphasized meaningful work provided to all. This emphasis was supported by strengthening “whole person” education that developed not only the mind but also addressed the physical, social, emotional, and spiritual experiences and concerns of students. Where wealth was concentrated, there was an attendant expectation that the bearers of that wealth would play a disproportionate role in meeting global and local needs. Governments around the world also levied new taxes on the automation technologies that had replaced human labor. These governments then used the revenue to fund skills training and personal development for graduates seeking work in areas that they found personally meaningful, or where robots and artificial intelligence could not compete.

The increase in human development, which accelerated throughout the 2020s, enlarged the pool of beneficiaries of and contributors to the “global brain.” Governments set ambitious goals for early-life learning among their populations, but also raised the levels of learning at all age and income strata. By 2030, the synergies between human and machine intelligence have allowed a large cohort of young people...
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to develop leadership capacities in many fields and endeavors. Neuroscience studies have demonstrated that young people raised on computers and mobile devices have faster cognitive processes and are more adept at lateral, integrative thinking than their elders.

In the late 2020s, curricula in engineering and other hard sciences incorporated theories from the social sciences so that graduates could have a holistic understanding of the place and role of their expertise in the broader environment and society. Likewise, ideas from computer science and the life sciences were integrated into the social sciences. As a result, in all fields, generators and users of knowledge adopted a broader scope of interest. Given their impact on daily life in the 21st century, engineering and computer science in particular gained a reputation as “the new liberal arts,” offering core knowledge that informed people’s thinking throughout their lives and careers. As the walls between different types of expertise crumbled, all the talent in the world could be engaged in collaborative processes of innovation. In fact, by 2030, the most successful innovations have come from teams that combined experts in diverse fields that historically had not often collaborated.

Global governance bodies addressed the growing role of technology in 21st century life. By 2021, the United Nations adopted a seminal treaty on technology and science that outlined principles for the deployment and use of scientific research and applications. Coming out of an international dialogue organized by a small group of cooperating professional associations, these principles conveyed the shared aspirations of scientists, politicians, businesspersons, and citizens. Following one of these principles, most scientific curricula in primary education around the world incorporated deep scientific knowledge into early stages of education. Online tools such as didactic games and interactive and immersive learning portals rendered classroom teaching entertaining and inexpensive. Children started to see science as accessible and fun.

This influential global treaty on technology and science supported the move towards global harmonization of standards for technology, communication, and other applications, enabling worldwide cooperation without regional barriers. Networked experts and organizations were able to constantly evolve standards that provided coherent guidance for both local adaptation and global adoption. Strategic standards for the betterment of humanity became a global public good. In fact, in 2030, standards with ethical implications are required to be open-source as well as open-access to the general public. Newly introduced strategic standards included global leadership standards emphasizing global security, social and economic equity, and environmental protection. A few years after the treaty, engineering education incorporated the need for and meaning of standards, as well as knowledge of standard design.

Fortunately, the global intellectual property (IP) system evolved rapidly to support the rapid diffusion of new capabilities and innovations in an ever more complex technological environment. By 2025, a global IP clearinghouse had been created with the mandate of ensuring an equitable distribution of innovations. This new system deployed a range of differentiated approaches to IP incentives that optimally addressed societal and environmental challenges. Some major innovations came through open-source channels, developing and diffusing quickly with the support of networked experts worldwide. Other inventions were trademarked through a global patent system that saw significant improvement over the years. Global harmonization enabled patents to cascade across jurisdictions with virtually no time lag. In the networked world of 2030, opportunities to pool patents and develop licensing agreements have become global engines that attract investors from all over the world, thus propelling economies worldwide.

The expansion of the global knowledge network both caused and drew upon significant improvements in the exchange of knowledge through meetings and conferences. Between 2015 and 2025, as the global knowledge network emerged, conference design entered a transformative period. Conferences became fully tailored to each attendee, providing them with personalized networking tools and personalized learning support, including flexible and affordable learning modules with mentorship by humans and machines. Conferences were delivered through a diverse array of modalities ranging from virtual to physical to mixed. The degree of personalization and the range of formats available offered opportunities to attend high-quality events to people who could never have attended such events in 2013. Great speakers—whose intensive training and testing ensured full audience engagement—sparked dialogues that were coordinated by tech-savvy facilitators whose familiarity with each participant’s interests, needs, and capabilities made meetings fulfilling for people in all professions.

As disciplines and professions became more fluid throughout the 2020s, multiple mergers occurred in the association world. Through a dynamic process of differentiation and integration, “umbrella” associations coordinated a vast range of “sub-associations,” ensuring they remained independent enough to create and cultivate their own locally relevant innovations. In 2030, associations play such an important role in the networked world.
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role that both governments and corporations actively court their support, knowing that this has become an important arena in which solutions to the world’s great challenges are likely to emerge.
Scenarios for IEEE – Part 1: Four Scenarios to Inform IEEE's Strategic Thinking

Scenario 4 – Distributed Talent for Good
Aspirational Zone

The decades leading to 2030 were characterized by a global mobilization of distributed talent and expertise around shared interests and intent. These changes occurred in the context of massive shifts in law, technology, education, and society. Although many of these changes were already underway in 2013, most were visible only at the margins, where they often escaped attention.

What became evident in the 2010s was that the global system of intellectual property (IP) protections had in many cases become a hindrance to the innovation it was designed to promote. “Patent trolling” by major corporations had already caught the public’s attention. In 2016, a widely-publicized study showed that patents that were too broad in those scientific and technological areas where innovation was expensive effectively reduced the volume of overall investment in those areas. The net effect was a debilitating reduction in the overall volume of innovation in areas vital to human advancement.

IP protections also faced new challenges as proprietary products and services were increasingly viewed as essential to participation in 21st century life. As governments increasingly sought to make these goods available to their entire populations, IP protections came under increasing public scrutiny and legal challenge. One milestone in this process was a 2022 U.S. Supreme Court decision that declared software patents invalid, on the grounds that software was a public good and that access to software was a human right. Meanwhile, NGOs and social justice movements worldwide denounced IP protections for what they saw as corporate abuses.

At the same time, the generation and distribution of products and services became increasingly open. Many start-ups experimented with new approaches that “co-created” (see Box 1, p. 3) products and services with customers and stakeholders, often including community members and even competitors. The early success of a few open-source endeavors in the 2010s—such as Protei, an open source oil-spill cleaning robot—inspired thousands of major projects and millions of micro-projects worldwide. By 2020, co-creation had become pervasive in hardware and software engineering applications in sectors ranging from information and communication to energy and the environment. Similarly, by the mid-2020s most scientific and technical publications had become community-reviewed through online annotations and ratings. Many experts crowd-sourced their articles, publishing an initial prompt or question and then allowing the crowd to create new knowledge in response.

While this movement towards openness had been gaining prominence since the 2010s, what was hard to foresee in 2013 was how well the quality of crowd-sourced and open-source creations was maintained. Online rating communities grew increasingly sophisticated in their ability to qualify, rate, and rank their members, and to establish exclusion criteria. Moreover, an increase in the transparency of online information discouraged behaviors such as “hiding” or “trolling.” With quality assured, new business models emerged and expanded, including “long tail” revenue models that drew only a few cents from each payer but provided large rewards in aggregate for the generators of content that went “viral.”

The combination of a collapsing IP system with a new open model of learning and working struck a death blow to traditional knowledge gatekeepers such as publishing houses, academic journals, and associations. The decline in revenue from proprietary publications, both print and digital, accelerated in the mid-2010s. By 2015, a major scientific and technical professional association had reported that its entire publishing line had gone out of business. Layoffs in the association sector became commonplace, as many associations shifted to volunteer-only models or outsourced their management. Many associations had to raise their membership fees to survive the revenue losses of publications, courses, and conferences. This had the effect of pulling more members away from subscribing. Competition raged among associations in similar areas, which morphed into small businesses marketing a set of products and services to a particular profession. By 2020, many associations had been reduced to a handful of diehard loyalists who created discussion forums on whatever social networking platform was most fashionable at the time, and organized low-cost in-person gatherings when possible.

In some of these circles, members found new ways to self-organize around shared affinities in order to exchange knowledge for free and to connect with experts and lay people. As they self-organized, they discovered other groups that had already been set up around the same topic outside the traditional association infrastructure. Some members recognized an opportunity to meet needs that all of these groups had in common, but that none could meet on its own. By developing a menu of broadly demanded products and services, they tied these groups together and created others, building a vast network of autonomous “cells” or “nodes” that emerged and disappeared organically. Having developed this network, these pioneers created a range of business models that allowed them to be compensated for their efforts.
Scenario 4 – Distributed Talent for Good

Aspirational Zone

This evolution of the association model was in line with changes in other parts of society. In the mid-2010s, many leaders of organizations had realized that although information, knowledge, finance, and the media had all been democratized in the Internet Age, organizational structure had not. The workforce increasingly expressed resistance to hierarchy by pushing for more collaborative structures built on trust and respect rather than on the power of positional authority. As a result, by the 2020s, organizations had become divided into smaller teams that were more conducive to personal relationships based on trust. These teams were often temporary, combining the efficiency of people who had been working together for a long time with the fresh perspectives of new team members. A range of tools was available that enabled rapid formation of teams with relevant skills through matchmaking platforms, rapid fundraising (e.g. through crowd-funding), and rapid prototyping (e.g. through 3-D and 4-D printing). Team members were thus able to manage a variety of engagements that together provided a sufficient livelihood. Staff functions such as finance, planning, and human resources were distributed among these teams. Thus, by 2030, many companies in the private sector have reached the same endpoint as had been discovered by innovative members in traditional associations.

These shifts required significant changes in the education system. In the 2010s, the number of people enrolled in Massively Open Online Courses (MOOCs) expanded dramatically. To provide open access to knowledge, big Internet players joined forces with teachers and experts worldwide, from alternative platforms such as the Khan Academy to individual expertise exchanges such as Google Helpouts. These new technologies opened access to knowledge for populations which previously did not have access to lifelong training or even formal schooling. As learning modalities proliferated, credentials from traditional institutions (e.g., universities or certification boards) became irrelevant. They were replaced by adaptive learning and assessment platforms that prepared people for distributed work and innovation. Enrollments at traditional universities fell, particularly as tuition fees reached unsustainable levels. By 2021, Ivy League universities in the U.S. had launched ivy.edu, a learning platform with differentiated learning offerings (with varying degrees of personal attention, mentorship, or networking opportunities) across a range of price points. By 2020, a well-known university in London closed its doors, shifting its content completely online. This model was soon followed by many state universities in the U.S.

By 2030, the wide distribution of knowledge has informed and tapped a wellspring of innovations with high potential to improve the human condition. These innovations connect to each other rapidly, reframing major challenges at the local and global levels. Individuals reach their full potential through multiple roles on a variety of teams working in different fields and sectors. The result is an unprecedented unleashing of human capacity, which has led to major breakthroughs in energy, transportation, communications, and space exploration.
### Scenario Matrix

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<thead>
<tr>
<th>EXPECTABLE</th>
<th>CHALLENGING</th>
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<tr>
<td><strong>Global Intelligent Networks</strong></td>
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<tr>
<td>• Big Data flowing from human communications, huge online databases, and ubiquitous sensors is integrated into global intelligent networks that provide highly accurate and tailored knowledge.</td>
<td>• Corporations and surveillance agencies invest in advanced analytics to process big data.</td>
<td>• Integrated global intelligent network functions like a “global brain” based on a virtual neural network of human-machine interfaces.</td>
<td>• Global intelligent network is composed of autonomous “cells” or “nodes” of people connected by associations, workplaces, and other platforms.</td>
</tr>
<tr>
<td>• However, the networks fail to help humans anticipate and prepare for the future.</td>
<td>• Corporate and government interests shape and dominate knowledge networks.</td>
<td>• The network’s infrastructure is seamless across geography and providers, improving worldwide transparency and accountability.</td>
<td>• This new node-based work structure has been spearheaded by a handful of visionary associations.</td>
</tr>
<tr>
<td>• Disadvantaged communities worldwide do not have access to the global networks’ infrastructure.</td>
<td>• A large part of the world population lacks means to access knowledge.</td>
<td>• The network is able to ask the right questions of the right people at the right time and place.</td>
<td>• These platforms use new business models to connect, spark, and nurture teams and initiatives.</td>
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<tr>
<td>• Ubiquitous surveillance leads to “extreme safety.”</td>
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<td>• The network mobilizes the talent and expertise of all.</td>
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### Knowledge Creation and Dissemination

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<tr>
<td>• Knowledge delivery involves a range of multimedia tools to facilitate learning, from videos to digital badges.</td>
<td>• Information overwhelms the majority of the world’s population, despite highly personalized curation services.</td>
<td>• Knowledge delivery technologies are intuitive and adaptive to people of all ages.</td>
<td>• Community reviews successfully ensure high quality of much scientific and technical content.</td>
</tr>
<tr>
<td>• Demand for open access to online knowledge spurs new business models.</td>
<td>• Knowledge is concentrated into a few islands of power.</td>
<td>• Highly tailored knowledge is integrated into everything people do via pervasive wearable technologies.</td>
<td>• Some content creation is crowd-sourced.</td>
</tr>
<tr>
<td>• Longstanding publishing bodies gradually lose legitimacy.</td>
<td>• Transparency is a burden rather than a tool for consumer empowerment.</td>
<td>• Access to high-quality knowledge is open to all.</td>
<td>• Populations who previously did not have access to lifelong training or formal schooling can now access the knowledge network.</td>
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<td></td>
<td>• Popularity surpasses quality in ratings.</td>
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<tr>
<td><strong>Workforce</strong></td>
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<tr>
<td>• Robots gradually replace manufacturing and expert work.</td>
<td>• Engineering and informatics professions are reduced to a small elite that is relentlessly pursued by corporations and governments.</td>
<td>• Worker mobility increases thanks to widespread use of adaptive knowledge technologies.</td>
<td>• The nature of employment fundamentally changes worldwide to rely on multiple affiliations and collaboration.</td>
</tr>
<tr>
<td>• Educated, tech-savvy workers favor new, more flexible work engagements.</td>
<td>• Particularly in engineering and other scientific professions, the gap between industry needs and workforce qualifications widens.</td>
<td>• Holistic education, new tax systems, and global ethic of fairness support human development.</td>
<td>• Online matchmaking tools allow teams with complementary skills to form rapidly around the globe.</td>
</tr>
<tr>
<td>• Unemployment becomes endemic among people whose educational attainment is low.</td>
<td>• Growth without jobs: Automation increases economic profits without job creation.</td>
<td>• The “global brain” nurtures leadership qualities among larger groups of people.</td>
<td>• The new organization of work facilitates the integration of disenfranchised communities in local economies.</td>
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| Scientific Disciplines | | | |
| • Scientific silos continue to break down. | • Funding cuts in research and education in STEM (science, technology, engineering, and mathematics) and informatics. | • United Nations adopts treaty on ethical deployment and use of science and research applications by 2021. | • Many hardware and software engineering endeavors are crowd-sourced or co-created by designers, customers, and other stakeholders. |
| • Collaboration skills (e.g., T-shaped scientists) become as essential as subject matter expertise. | • Basic science research is devalued compared to applied scientific research. | • Engineering and computer science become “the new liberal arts.” | • Education—including scientific education—is delivered to people of all ages through adaptive learning and assessment platforms. |
| • Collaborative platforms enable cross-disciplinary work. | • Innovation becomes exploitation of the many by the few, rarely used for solving pressing global challenges. | • Hard and social sciences incorporate theories from each other. | • Credentials from traditional institutions become irrelevant. |
| | | • Children gain deep scientific knowledge early on. | |
## Scenario Matrix

### Intellectual Property

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<td>The conventional IP system remains dominant, incentivizing investments in innovation.</td>
<td>The global IP system becomes regionalized, with varying degrees of effectiveness among regions.</td>
<td>A global IP clearinghouse is created to ensure fair access to innovations.</td>
<td>Many proprietary products and services (e.g., software) are recognized as essential to participation in 21st century life, challenging the conventional IP system.</td>
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<tr>
<td>However, insufficient global enforcement and frequent patent-trolling weaken IP rights.</td>
<td>IP systems compete to control rather than share knowledge.</td>
<td>The global IP system is organized around differentiated approaches to address societal and environmental challenges.</td>
<td>NGOs and social justice movements denounce IP protections seen as corporate abuses.</td>
</tr>
<tr>
<td>Reforms of national IP systems fail to address global IP issues.</td>
<td>Not all IP systems provide enough economic incentive to invest in innovation.</td>
<td>Effective patent pooling and licensing agreements attract investors.</td>
<td>Generation and distribution of many products and services become increasingly open.</td>
</tr>
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### Technologies and Generations

- Technology becomes an additional layer in defining generational cohorts.
- Technology creates new global communities of “tech haves”, but becomes another obstacle to overcome for “tech have-nots”.
- Impacts of technologies on the brain (e.g., multitasking) are scientifically explored.
- Important knowledge from past generations is lost among rapid technological change, slowing down innovation.
- The gap between technology “haves” and “have-nots” widens.
- Technology of choice no longer segregates people of different ages and backgrounds.
- Impact of technologies on the brain (e.g., faster cognitive processing) are scientifically shown as enhancing the cognitive capacity of a large generation of young leaders.
- Technologies no longer define generational differences.
- Instead, technologies facilitate intergenerational mentorship and transfer of knowledge.
## Scenario Matrix

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<td><strong>Standards</strong></td>
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<tr>
<td>• Rapid technological change and acceptance worldwide require fast production of interoperability and safety standards.</td>
<td>• Global standards system, particularly in the sector of information and communication technologies, breaks up into regional blocks.</td>
<td>• Worldwide harmonization of standards.</td>
<td>• Associations and other facilitator organizations support participation in standards setting by manufacturers, users, and other stakeholders.</td>
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<td>• Harmonization of standards across nations and industries improves.</td>
<td>• Countries use “digital embargos” on each other to preserve parochial interests.</td>
<td>• Strategic standards for the betterment of humanity, including global leadership standards, are a global public good.</td>
<td>• Standards in many areas are open access.</td>
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<tr>
<td>• Standard-setting organizations experiment with new processes and business models to embrace harmonization and respond to competition.</td>
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<td>• Standards are an intrinsic part of engineering education.</td>
<td>• Standards take ethical, societal, and environmental concerns into account in most sectors.</td>
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<th>Conferences</th>
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<tr>
<td>• The patience of attendees for low-quality conferences declines.</td>
<td>• General aversion to sharing knowledge undermines value of conferences.</td>
<td>• Modes of conference delivery span the range from virtual to physical.</td>
<td>• Conferences are opportunities for learning, meeting, and fast prototyping of emerging ideas.</td>
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<tr>
<td>• High-quality conferences offer participants advanced networking tools and real-time rating of speakers.</td>
<td>• Attendance declines due to negative perceptions of conferences’ return on investment.</td>
<td>• Conferences become accessible to populations who could not participate in them before.</td>
<td>• Conferences emerge spontaneously, often organized to meet the needs of local communities.</td>
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<td>• Higher fees for invitation-only conferences often cover delivery costs.</td>
<td>• The conference business becomes concentrated among a few providers.</td>
<td>• Audience engagement improves due to high degree of personalization and interactivity.</td>
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<tr>
<td>• Demand for energy—including, increasingly, clean energy—continues to rise globally.</td>
<td>• U.S. investments favor existing technologies over new, more climate-friendly ones.</td>
<td>• Energy is one of several grand challenges that have been successfully addressed by 2030.</td>
<td>• Energy is one of several grand challenges that have been successfully addressed by 2030.</td>
</tr>
<tr>
<td>• Technical advances in energy efficiency, storage, and renewables (particularly solar).</td>
<td>• In Europe, too much regulation causes energy prices to soar up.</td>
<td>• Hardware infrastructure optimizes use of energy and rare materials.</td>
<td>• Groundbreaking scientific discoveries in production and distribution techniques are brought to scale.</td>
</tr>
<tr>
<td>• Fossil fuels remain the dominant energy source.</td>
<td>• Periodic power outages disrupt the entire energy system worldwide.</td>
<td>• Fossil fuels fall below 20% of the global energy mix.</td>
<td>• These discoveries enable a shift to low-cost distributed renewable energy sources.</td>
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<td></td>
<td>• Worldwide agreements promote energy efficiency and affordability.</td>
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Conclusion

Alternative futures provide a new frame for planning and decision making by calling into question the implicit assumptions we carry with us from the past. A planning process based on the exploration not only of the expectable future but also of challenging and aspirational futures that go beyond conventional expectation creates a broader awareness of the futures that may unfold. One benefit of this approach is that it helps an organization identify strategies that are robust across several or all of the scenarios. These strategies can essentially be thought of as future-independent—that is, they make sense no matter what the future holds.

There is another benefit to this approach. In introducing the “aspirational futures” method, we spoke of the two distinct lenses that this method applies to the future. An objective lens clarifies what is likely, while a subjective lens focuses on what is most meaningful and would be preferable. A tension may arise if the most likely future is not the future that the organization would prefer. This tension can motivate the organization to identify a feasible set of strategies that would make the preferred future more likely.

As it converts its learning from this systematic exploration of the future into the specific actions it will take over the coming years, IEEE has the potential to achieve even greater successes in the future than it has in the past. IAF invites IEEE leaders to be bold and deliberate as they envision the powerful role that IEEE can play in assuring humankind derives the greatest benefits from innovation.

Please email IEEEstrategy@ieee.org with any questions, comments, or to share the work you are doing with these scenarios.