Predicting Technologies That Advance Humanity

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The third annual "Predictions" issue of Computer covers a diverse range of technical topics including the Internet in space, data center networking, the carbon footprint of machine language training, human–centered artificial intelligence design and the digital divide.

In the age of COVID-19 pandemics and raging war in Europe, knowledge concerning humanity, sustainability, and societal issues are of the most concern in our daily lives and to the survival of the human race. The IEEE tagline is "advancing technology for humanity." This issue of *Computer* inherently reflects this tagline and directly contributes to IEEE and the Computer Society's (CS's) mission represented by this slogan.

In this same age of COVID-19, we have learned, the hard way, of the critical importance of diversity. For this special issue, we received 14 articles, and we accepted five, resulting in an acceptance rate of 35%, which is respectable for a very focused column on technology predictions. Although our primary criterion for acceptance was high quality, we were pleased that the resulting collections was also highly diverse across many dimensions.

Two accepted articles are written by authors across industry and academia, one is from academia only, one is from industry only, and one is across academia and a research institute. One article is written by female author only, two are by male authors only, with two by both female and male authors. We had authors from three global regions of the world Asia (India), Europe (Germany and the United Kingdom), and North America (Canada and the United States).

Diversity also exists in terms of technology domains. Two articles address communication technologies [low-Earth orbit (LEO) satellite communication and data center networking].

Two articles address artificial intelligence (AI) [carbon footprint of machine learning (ML) training and human-centered AI design] and one investigates a societal aspect (the digital divide). Four articles explore systems issues and two address regulatory compliance.

The articles in this special issue are visionary, looking beyond current horizons and into the future of, for example, space travel, convergence of mega data centers and high-performance computing (HPC) supercomputers, and the future of ML training. Yet, all the articles are primarily driven by humanity concerns, ranging from challenges of the digital divide in marginalized communities, concerns in human-centered AI design, and the carbon footprint of cloud datacenters.

For example, in "The Carbon Footprint of Machine Learning Training Will Plateau, Then Shrink," Patterson et al. make a prediction about the sustainability costs of ML training. The authors challenge existing concerns about carbon emissions, demonstrate much lower values for cloud datacenters, and predict further decreases due to a variety of techniques, such as improved models, new optimized accelerators, and selection of choices with optimal power usage effectiveness and carbon intensity (a measure of the cleanliness of a datacenter's energy).

"The Convergence of Hyperscale Data Center and High-Performance Computing Networks" by Hoefler et al. explores the convergence of HPC and data center networks. They predict many dimensions where this

convergence will take place as well as where differences will remain. According to the authors, the primary catalyst for convergence will be smart network interface cards. The convergence itself will be driven by innovation in HPC domain while datacenters will have to maintain backward compatibility and be limited to incremental adoption. Networking stacks in both domains will undergo changes. Although convergence will continue at the application level, the networking level will continue to support inherently different requirements.

In "Space Broadband Access: The Race Has Just Begun," by Yiming Huo, the general availability of LEO satellites and affordable launches are the basis for predictions of advances in space communication. These advances will enable access to areas on Earth without Internet access, communication in space close to the Earth, as well as with distant planets, starting from the moon and Mars. Driven by competition and based on economic laws, the cost of space communication will continue to decrease, while bandwidth will increase. Early entrants, such as SpaceX Starlink, OneWeb, and Telesat are being joined by companies such as Amazon and Boeing.

Ria Cheruvu's "Unconventional Concerns for Human-Centered Artificial Intelligence" explores a variety of scenarios where AI increases attack and bias surfaces. The different ways of engaging humans (in the loop, on the loop, and outside the loop) and their relationships to the complexity of AI algorithms, the author predicts, will have a substantial impact on

vulnerabilities. This, in turn, will have a drastic impact on technology, regulations, and societal aspects. The author makes specific predictions about the autonomy and transparency of AI in the next 10 years.

Finally, "Challenging the Digital Divide: Factors Affecting the Availability, Adoption, and Acceptance of Future Technology in Elderly User Communities" by Marimuthu et al. explores technology adoption models and gaps among marginalized communities of people, such as elderly or indigenous populations. They especially analyze inequalities created by reduced socioeconomic development caused by the lack of education and financial constraints. They consider access, usage, skills, lack of motivation, and emotional barriers. They propose training, assistance, emotional support, addressing security problems, and policy framing. They conclude with a formal classification of requirements and gaps to be addressed to enable transition of elderly people to the digital world.

This is our third special issue of *Computer* on technology predictions. The idea originated from the annual technology predictions team, which traditionally made end-year predictions for the following year, including a self-evaluation of the previous year's predictions in the form of a scorecard.[1] It also derived substantially from our original CS Report 2022, which we wrote more than eight years ago.[2]

The first special issue was an experiment conducted on short notice and without much visibility in the community. The annual technology

prediction team wrote most of the articles with some assistance from additional invited authors.[3] The second *Computer* special issue had a well-planned call for papers and a spectrum of interesting topics.[4] This third issue has again surpassed our expectations in terms of the number of submissions and quality of articles, and we plan to continue our regular annual special issues as long as our audience shows interest.

In addition to special issues, we also refer you to the "Predictions" column, which has been appearing every other issue for a year now, on such topics as clouds, accelerators, silicon photonics, and HPC. They appeared, respectively, in the October 2021 and January, April, and July 2022 issues of *Computer.*

We hope you enjoy this special issue and would very much like to hear from you about

it, particularly recommendations for improvements. Thank you to all who have already approached us, and many thanks to all the authors and reviewers of submitted and accepted articles. **C**

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