Predicting the future of information technology and society

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A YEAR AGO, this column contemplated the road ahead for semiconductor-based *products* that build on basic design, test, process, and device *technologies*. In late 2011, a workshop on the "Future of IT and Society" presented several broad visions of how *societal changes* will build on semiconductor-based products and information technology in such contexts as social mobility, healthcare, security, and mankind's relationship to the environment. Prediction of "the road ahead" at a societal level—with a meaningful time horizon (and with causal connections to underlying product roadmaps that connect, in turn, to underlying technology roadmaps)—presents a daunting, yet invaluable goal for researchers, governments, and entrepreneurs alike.

Predictions for IT and society—right and wrong

Over the years, predicted futures for IT and society have come from many sources: scientists, business leaders, futurists, novelists, film makers, and various formal efforts such as the Millennium Project's annual *State of the Future* report. Very few nontrivial predictions survive 20-20 hindsight with respect to all their facets: technology, functionality, usage, societal impact, and timing. Yet, several stunningly correct predictions have been made. At the 1987 Educom, Apple's then-CEO, John Sculley, described the "Knowledge Navigator," a tablet-like device that could access a large networked database, with software agents to assist the search for information. This foresaw the functional integration of mobile audio/visual communication, mobile computing, wireless internet access, remote access to other appliances, and both touch-screen and natural-language voice interfaces. Mark Weiser's 1991 article on the "computer for the 21st century" correctly predicted the emergence of ubiquitous computing over a 20-year span, with "TAB" (pocket-size) and "PAD" (page-size, with pen interface) devices, and "BOARD" (meter-size) displays. The scenario depicted in the article incorporated natural-language voice interface, thin displays, RSS feed, remote data sharing and telepresence, automotive navigation systems, and many other realities of today.

There have also been many erroneous predictions, which may be classified into three types. First, there are *pessimistic* predictions, such as Western Union's 1876 declaration that "the [telephone] is inherently of no value to us," or Bill Gates' famous remark in 1981 that "640 K ought to be enough for anybody." These are rather benign, in that they are corrected by the march of progress. Second, there are *optimistic* predictions: Tesla's belief in 1909 that mobile communications would be coming soon, or Roger Smith's 1986 prediction that we would soon live in a paperless society. Such predictions, whose optimism is typically with respect to infrastructure, costs, transition overheads, and similar factors, have benefits in that they open our eyes to what is possible. Third, there are *nonpredictions*, where the world fails to foresee a change until it becomes a reality. The long list of examples for this category includes the world-wide web, Wikipedia, social

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networking, open-source, and convergence platforms for mobility. Futurists and leading technology companies simply didn't see these coming.

How well can we predict the future?

Consider that the semiconductor industry's technology roadmap has a 15-year horizon, and that the product roadmaps of most semiconductor companies look at least three to five years into the future. Why, then, is it so difficult for futurists to predict the next Google or Facebook? I believe that there are at least three reasons for this. First, comparing "roadmapping" to "futurism" is unfair: these are apples and oranges. A typical technology roadmap consists of challenges, requirements, and potential solutions at specific points in time; it addresses only a narrow domain (e.g., on-chip interconnects); and it can get by with a large element of extrapolation and "driving by the rear-view mirror." By contrast, futurism has an inherently wider scope that includes psychology, sociology, politics, economics, the arts, and more. More crucially, futurists almost by definition seek to predict the *nonobvious*. It is much more difficult to foresee a "tipping point," an "S-curve," or "disruptive innovation" than it is to perform "trendspotting" or "technology sensing." Second, when technologies and products change, this can, in turn, induce very rapid changes of societal trends and human habits. At the same time, the pace of technological change usually depends on factors such as price and infrastructure, rather than on people. Thus, it is easy to make short-term mispredictions. Third, futurists must contend with an exponentially increasing pace of technical change. Where millennia once separated the innovations of spoken language, agriculture, and the wheel, now only a few years separate more recent innovations such as personalized medicine and massively free online education. Indeed, mankind may be approaching the "singularity" predicted by Ray Kurzweil in 2005—"a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed"? If this is the case, then futurism will become, er, futile.

How will we predict the future of IT and society?

Is it possible to predict the future of IT and society? Pessimists can point to the difficulty of temporal accuracy, and to how rapidly the world around us is changed by 22 nm FinFETs, Arab Spring, or the cloud. It is also hard to predict societal norms and needs with respect to safety, privacy, and other basic issues. Optimists can note that several key future drivers for IT and society—including health, aging, sustainability, energy, ubiquity, and entertainment—are increasingly well-understood. We can also draw encouragement from the existence proofs of prediction accuracy at 20+ year horizons (e.g., Apple's Knowledge Navigator). Many predictions that are already embedded in books or movies may turn out to be accurate at longer horizons. And, given the volume of technological discovery in recent decades, perhaps there are fewer technology revolutions that remain to be discovered, which would ease the task of futurists as well.

I PERSONALLY BELIEVE that a true "science of futurism" will be developed within the next decade. Not only are there strong incentives to better model and predict the interplay between information technology and human society, but there is a steady stream of enabling techniques from big data, machine learning, modeling, and simulation. Nascent methodologies and metrics can already be found in, e.g., the Millennium Project's "Futures Wheel" and "State of the Future Index." What new frameworks, processes, and tools can better connect "roadmapping" with "futurism" to improve the future of IT and society? Answering this question is a key challenge on the road ahead. As always, I welcome your feedback. ■

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