INIT

The Future of Devices: A reality check

I was watching the newest episode of "Black Mirror" with my best friend the other day. While we were watching, he suddenly asked me, "You know why it is called 'Black Mirror,' right?" To be honest, I never thought about it, so I told him that I did not know. My friend explained to me that the title is a reference to the reflection you see on a device when you turn it off—i.e. an actual black mirror.

Many viewers, myself included, enjoy watching "Black Mirror" because it shows vast and dramatic possibilities of how our lives may be impacted by futuristic devices. I am amazed at the play writer's great imagination of how future devices may look like. People have long been fascinated in predicting utilities and physical forms of future devices; there are tons of articles titled something like "10 Predictions on Future Devices." But what is on your mind when you think of future devices? Perhaps buzzwords like AI, robotics, 5G, medical IoT, or maybe quantum computers? If you feel like it is hard to tell what future devices may do or how they may look like, you are not alone.

In this issue, we are going to take a deep dive into technologies that drive the development of futuristic devices. But first…

What is a future device?

According to Google, a device is "a thing made or adapted for a particular purpose, especially a piece of mechanical or electronic equipment." As we are computer scientists, we will focus on futuristic electronic and computing devices in this issue. We mainly look at their utilities. Specifically, how we perceive a device as a thing that achieves a certain purpose, for example, mobile phones for making a phone call.

Future devices are often unexpected.

One of the most well-known quotes from Henry Ford is, "If I had asked people what they wanted, they would have said faster horses." While some of the devices are the outcomes of the true prediction of some sci-fi movies or comedies (like in "Futurama"), many more seem to come out of the blue. We are living in the "Age of Surprise" [1], where determining what may be the next major hit is more difficult than ever. For example, immersive AR/VR glasses, quantum computers, and smart-home assistants, among so many others, may not have been on the imaginations of the general public in the early 20th century.

However, even future devices that achieve similar functionalities with their predecessors, could evolve so much in their physical forms, such that they share almost no similarity in their looks. For example, who could have thought the big, chunky mobile phones with keyboards and visible antenna in the 1970s would evolve into the piece of small, foldable "black mirror" we put in our pockets?

Future devices are driven by solid technology breakthroughs.

Needless to say, future devices are only possible thanks to scientific progress. A foldable smartphone would not be possible if there were no reliable touchscreens. A quantum computer would still be a few physicists' thought experiments if it were not for the reliable qubits.

In her welcome letter, co-Editor in Chief Diane Golay shared with us her three wishes on future devices. I have the same wish for "longer autonomy." Fundamentally, this issue is caused by the disproportionate

2020 **By next year, China and India together will have 2.6 billion mobile phone connections out of a total of 4.68 billion global connections.**

growth of computing power versus a device's energy capacity. While the growth of CPU computing power has been, so far, mostly following Moore's law, the total capacity of lithium-ion batteries in our phones haven't improved that much over the past five years [2]. While phone vendors are trying their best to stuff more batteries in our phones, future devices could benefit a lot more from fundamental technological breakthroughs, such as better battery materials for higher energy density and/or better device energy management [3].

IN THIS ISSUE

In this issue, we are performing a reality check on the challenges associated with modern and future computing devices. We have assembled a range of articles from renowned academic researchers and industry experts explaining some of the most exciting advances in making futuristic devices possible. We have put fancy imaginations aside and are focused on the underlying technologies. These articles cover various aspects of future devices, including their utilities, user interface, programming language, new methods of communication, security and privacy issues, scalability and deployment challenges, and so on.

We first bring you three articles discussing some truly futuristic devices that are nothing like your classical computer. Dr. Jens Palsberg from UCLA, and also the chair of ACM SIGPLAN, shares his thoughts on how to design a universal programming language of quantum computers. This is especially meaningful given the status quo that a quantum program can only run on one quantum computer as of mid-2019. Xiangyu Zhang and Ramin Bashizade, both Ph.D. students from Duke University, share a fascinating story on why we needed true random generators for probabilistic computing on future devices, and how to implement them using DNAs at the nanoscale. Dr. Jacob Sorber from Clemson University and Dr. Josiah Hester from Northwestern University share their design of a batteryless device, which is amazing and would be one way to fulfill Diane's wish for longer device autonomy.

We next introduce new ways of communication for future devices. The research team led by Dr. Xia Zhou from Dartmouth University share their experience of building Visible Light Communication (VLC) devices, which use light as a new physical medium for data communication. They showcase cool applications enabled via VLC devices and discuss associated challenges. IoT devices will probably be the most common devices in the future in terms of quantity. Dr. Deepak Vasisht and Guo Zhang from MIT envision in-body IoT for future medical applications. Their research addresses challenges of communication and localization for those IoT devices. The team lead by Dr. Lixia Zhang from UCLA present their ideas on how to use Named Data Networking (NDN) to replace the traditional TCP/IP network stack for future internet-of-things (IoT) devices to improve security and usability.

As future devices evolve, likewise do the way that we interact with our devices. We have two articles discussing assistive technologies for future devices. Dr. Monica Lam and her team from Stanford University share their vision on open virtual manifesto via a forward-looking manifesto, which stresses ethics and privacy issues. They tell a story on how they build Almond, a collaborative virtual assistant framework, to make the manifesto come true. Dr. Lars Oestreicher from Uppsala University shares his perspective on how to make use of assistive devices to enable people with special needs an equal access to technology.

Last but not least, Ph.D. student and researcher Nitin Shivaraman from Singapore's TUMCREATE discusses how to manage future IoT devices in a decentralized manner as scalability poses a challenge. Prashant Ravi from Realtek Singapore shares his experience on IoT design and his vision on deploying IoT devices for future smart cities.

THE FUTURE IS NOW

We hope you enjoy this issue, soak yourself with the contents, and appreciate the ongoing efforts made in both academia and industry to enable future devices. Though we mainly focused on the technology side, there are more aspects of future devices worth exploring. In the Winter 2018 issue of *XRDS*, readers were asked to dig into the question of hype versus innovation, looking at what enables innovative concepts to break through and become mainstream. We hope this issue has provided with some more insights into where innovations are needed, and what is required for them to survive and thrive in the market. We are calling for action. We firmly believe in everyone's eventual role as a user of future devices, but some of you will also be the designers of new emerging devices. As we are at the dawn of a new AI age, now is the best time to act.

—Zengwen Yuan, Guest Editor

References

[1] Tozer, J. L. Anticipating the age of surprise. Armed with Science (Jan. 14, 2013); https://science.dodlive.mil/2013/01/14/anticipating-the-age-of-surprise.

[2] Triggs, R. Fact check: Is smartphone battery capacity growing or staying the same? Android Authority (July 21, 2018); https://www.androidauthority.com/smartphone-battery-capacity-887305.

[3] Langridge, M. and Edwards, L. Future batteries, coming soon: Charge in seconds, last months and power over the air. Pocket-lint (June 17, 2019); https://www.pocket-lint.com/gadgets/news/130380-future-batteries-coming-soon-charge-in-seconds-last-months-and-power-over-the-air.

DOI: 10.1145/3351468