NEXT-GENERATION MOBILE COMPUTING

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THE PAST DECADE has seen immense growth in both the level of interest and the demands on mobile computing. Users are buying fewer stand-alone desktop computers but have been purchasing new mobile technology at an exponential rate to complement their personal computer needs. Within the last decade, laptop sales have surpassed those of desktop computers in many world markets, and the worldwide popularity of smartphones has surpassed them both (see the sidebar for further reading).

But smartphones are not the likely end of the mobile computing innovation vector. We believe mobile computing is in its infancy, and the next generations of mobile technology are going to be even more pervasive, smaller, and maybe even a bit weirder and more integral to our lives, jobs, and future.

Most commercially available mobile computing technology tends to iterate the same core concepts that made personal computers so popular and engaging. Smartphones connect us to our families and friends over wireless access points, the Internet, or cellular networks and provide entertainment via games, puzzles, and browsing. Larger tablets provide us with even more power on the go to connect and interact with the world. But these innovations are just the tip of the iceberg for the challenges that are on the mobile computing horizon.

Inventions like the Fitbit (www.fitbit.com) track our movements, heartbeats, sleep patterns, and overall health, and we can imagine users posting such information to their blogs and social media outlets to which other people can follow, track, and respond. Other pervasive devices like Google Glass (www.google.com/glass/start) present compelling use cases for augmenting reality for users and allowing them to experience and share their lives from a first-person perspective and in a way that is potentially more natural, resembling the type of wearable, immersive computing that was previously only possible in science fiction novels and movies. Both of these devices present very obvious challenges in privacy and security, but if these types of devices become truly integral to a large percentage of the world's technology consumer base, such small, pervasive devices could also overwhelm our networks—even more so than the worst-case fears over the consumption capacity of video and music sharing services like Netflix with regard to our Internet bandwidth.

What would we actually do if fifty million people attempted to stream video and data feeds from every waking moment of their lives? Even in fiber-optic–connected cities, the load would be overwhelming. Anyone who has gone to a fireworks display in a city of millions of people and tried to call out or even send text messages during the celebration can attest to the fragility of our current network and software infrastructures. What would happen if even 100,000 of those people at the celebration were trying to live stream their experiences?

The problem is even more compounded in rural environments, where we are actually in the midst of a surge of mobile computing innovation that is likely to change mid- and large-scale farming environments forever. The same unmanned vehicle technologies that have been used in aerial surveillance, bomb disposal, and search-and-rescue are being actively transitioned to tasks such as crop fertilization, pesticide and disease control, and border monitoring. Unlike the live streams of experiences such as fireworks shows, deviations or drops in communication in these situations could result in the catastrophic loss of expensive equipment or even lives from crashes of unmanned aerial vehicles, failure of mission-critical systems that control public utilities, or any number of exotic doomsday scenarios. Many of our protocols, like the reliable-communication-dependent windowing system of TCP or current cloud computing clusters, are simply not built for frequently disconnected operation, and expanding cell towers or wireless access points into all such areas is likely to be infeasible, especially across the entire world.

And then there are the frontiers of mobile computing that are as exotic and far removed from our personal lives as they are dangerous and important. Maritime and space exploration continue to rely on mobile computing innovations to expand our horizons, harvest new minerals, food, and other natural resources, and maybe even provide us with room to grow as a species. Indeed, the challenges facing mobile computing go beyond the difficult problems of enterprise-level scaling in a highly connected data cluster. Mobile computing is a frontier of hardware and software development that is likely to challenge every facet and resource of our technology sector.

The challenges facing mobile computing go beyond the difficult problems of enterprise-level scaling in a highly connected data cluster.

We, the guest editors of this issue,

TRENDS IN MOBILE COMPUTING

A clear series of trends have occurred over the past three years regarding mobile computing devices shipped. First, smartphone sales have risen dramatically and displaced the basic-feature phone market. By 2017, smartphone sales are expected to compose more than 95 percent of the mobile phone market share (see Figure A).[1,2] Similarly, tablets have recently caught up with PC sales of both desktops and notebooks and are expected to eclipse both in the marketplace during 2014. Desktop sales have declined every year since 2011, and laptop sales have stagnated for two years—likely owing to consumers choosing tablets for their mobile computing needs.[2–4]

Ultramobile computing has also seen growth, which has been doubling every year, and similar trends are expected in wearable computing. Wearable computing was valued at roughly US$800 million in 2013 and is expected to grow to $1.5 billion in 2014.[6] In this issue, we focus on some of the technical, software-related challenges of integrating these various mobile computing devices and their accompanying platforms into our businesses, networks, and social lives.

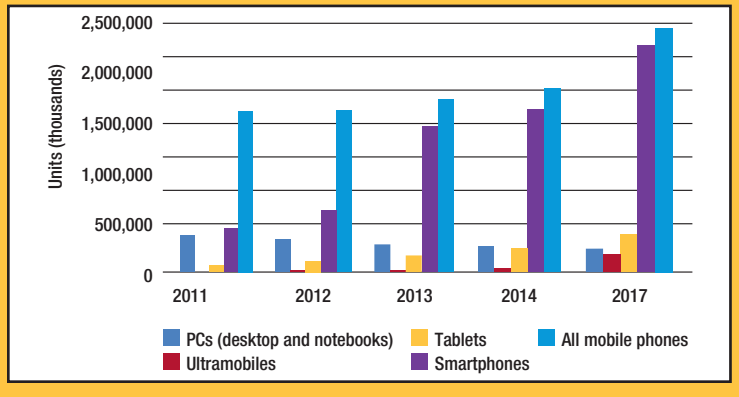

FIGURE A. A projection of mobile computing devices shipped from 2011 to 2017.[1–5]

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would like to be able to tell you that scale, social issues, and connectivity are hardware problems—that some new networking device or blackboxed security server will solve all of our biggest challenges, but such a belief is a counterproductive fantasy. The truth is that privacy, security, connectivity, and scale for mobile computing devices are going to need software innovations in infrastructure, networking, device management, and other fields that we may have yet to invent.

In this issue of *IEEE Software*, we glimpse into the near future of mobile computing by focusing on proximate software challenges coupled with promising techniques, infrastructure, and research from academia, government, and industry. We received many amazing submissions for this topic call, but we were unfortunately limited to choosing only a handful of interesting, relevant articles. We whittled down this submission base by specifically looking for research, techniques, and practices that could help drive interesting discussions and thoughts about some of the more immediate challenges in mobile computing—technologies and social movements that we believe will be readily apparent in the next five to fifteen years.

The solutions presented in these articles are not necessarily the ones that will find their way into the mainstream of mobile computing development, but we hope that these might lead to some of the high-impact ideas that will ultimately change mobile computing paradigms, connectivity, privacy, or infrastructures for the better. However, such an expectation is lofty. At the very least, we hope that you, the reader, will find these articles interesting.

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