Introduction

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The Internet was born in 1983. At least that is when it adopted TCP/IP (transmission control protocol/Internet protocol), the communications protocol that conceptually separates the Internet from its predecessors and continues to define it, technically, to this day. It was originally designed in an academic environment, funded by the kinds of deep public research funds on which basic science depends. The direction and shape of research was left largely in the hands of researchers, and they built a system only a researcher could love: general, abstract, optimized for nothing, and open to exploration of more or less anything imaginable using connected computers. Thirty-two years later, the Internet has become the most fundamental global communications and knowledge infrastructure of our age, and is fast becoming the basic data-and-control network of the coming decade. It has evolved over its thirty-two years from a network that primarily delivered email among academics and government employees, to a network over which the World Wide Web arose, to the video and mobile platform it has become – and the control network for embedded computing that it is fast becoming.

Could the Internet have been different? Could it still evolve into a fundamentally different platform than what we have grown accustomed to? What design choices did designers make that resulted in the Internet as we know it, and what design choices are we currently making that will shape it in the future? The essays we compiled for this volume represent an effort to offer some insight to both the research community and society at-large about what is at stake in this discussion and what different choices imply about the fu-

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ture of the Internet. The ambition of this collection is not to cover the entire gamut of challenges and design choices, but to offer a richly detailed exploration of the kind of analysis required across the board.

Our own individual essays in the issue frame this discussion, presenting broad definitions of the challenges and exploring the problems and opportunities they entail. In "The Contingent Internet," David Clark reviews the history of the design choices that made the Internet what it became, and outlines the range of design choices we are likely to face in the coming years. Yochai Benkler outlines, in "Degrees of Freedom, Dimensions of Power," the ways in which the first-generation Internet diffused economic, social, and political power, and the series of changes that has created new control points around which both nation-states and market actors are concentrating power and creating new design challenges.

Five subsequent essays dive deeper into particular design challenges presented by the emerging Internet. Peter Kirstein elaborates on what it would take, technically, to build an Internet capable of scaling to the billions, or perhaps trillions, of nodes that the "Internet of Things" (in short, sensors everywhere) will require. Deborah Estrin and Ari Juels examine, in "Reassembling Our Digital Selves," what design elements could make the power of ubiquitously collected data safely available to individuals as "small data," rather than emerging purely as "big data" analysis for the use of larger entities.

In "Choices: Privacy and Surveillance in a Once and Future Internet," Susan Landau examines the deep concerns about security and privacy, for both society and individual, that have pushed to the fore in our increasingly connected world. She then outlines the design choices that would make it possible to attain both values in the teeth of trends that seem to offer neither. In "As Pirates Become CEOs," Zeynep Tufekci examines the displacement of the public Internet by increasing reliance on proprietary networks, like Facebook, for the most basic communications capabilities. She identifies the new opportunities for manipulating consumer demand and political action, and discusses the power shift that lapses in Internet security cause and the stresses that an advertiser-supported Internet places on the open Internet. Finally, John Palfrey explores the "Design Choices for Libraries in the Digital-Plus Era," and the stakes of these design choices for the role of publicly spirited organizations in an increasingly privately owned networked environment, individualized and abstracted from place.

Several core themes emerge from the efforts of these seven essays to define the design challenges we face in the coming years of Internet evolution:

The technical is political. As Clark's framing makes clear, even in the early days of the Internet, designers understood that design choices had political influence, particularly at the level of recognizing potential tensions between large computer providers such as IBM and the telecommunications carriers. Three decades later – and after two decades of consistent work in law, philosophy, and social science – the secret is out: the technical is the political. Different design choices are subject to conflict among governments, corporate stakeholders, and Internet users, all of whom pursue power and their (at times conflicting) interests through these choices.

Both Clark and Benkler's essays provide a rich description of how design choices affect ethical and political values in concrete settings. In their contribution, Estrin and Juels very clearly explore the tensions between design choices that are conducive to "big data" – the collection of information by large data processors seeking to learn about, and thereby influence, their users or customers – and those design choices that would be conducive to "small data." The latter decisions could empower users to ac-

cess their personal data and use it to manage their own lives, as well as gain personal services that would not be possible otherwise, but at the risk of personal data exposure and against the challenge of wresting control of small data away from companies pursuing big data capabilities. Landau, in turn, outlines the tensions between creating an Internet system that prioritizes individual privacy and safety, and a digital environment that may be secure, but that nonetheless makes users vulnerable to the surveillance systems of service providers and governments. Tufekci explores how the design characteristics of different social networks influence the type of communication feasible: she describes how the different designs of Twitter and Facebook caused the two platforms to diverge in the degree to which their algorithms directed attention to recent political protests in Ferguson, Missouri; and how the shift to Facebook from open Internet blogs changed the nature of online publication in the Iranian and Egyptian public sphere. She then further examines how algorithms can influence users' political and economic preferences, with substantial implications on both economy and democracy.

Smartphones and Things. A second major theme that emerges from this collection of essays is that the nature of the endpoints of the network has changed radically since the early days of the Internet, and this, in turn, has changed the design choices and their implications. The early Internet connected general purpose computers that were fixed in location and often shared among users. A node was not a person, but a computer, and a computer was a general purpose device, not a specific appliance connected for control. Today, the majority of Internet users connect using smartphones, which are both personal and mobile. Kirstein's essay wrestles with the substantial challenges of building a network intended to serve over one trillion devices, many of them special purpose machines aimed at sensing and control systems, without substantial embedded intelligence. The essays by Estrin and Juels and by Landau both attempt to address problems that come from the fact that ubiquitous connected computing also functions as a pervasive surveillance and control network.

The privatized Internet creates new challenges, in particular for the continued role of public institutions. Palfrey's essay presents libraries as a microcosm of a much broader problem that the Internet has created. Like Tufekci, Palfrey starts with the fact that the platforms that most people use to access the Internet are privately owned. What role, then, do public institutions have in this privatized environment? Are they obsolete? Are they a necessary counterweight to an increasingly privatized space? Palfrey eloquently argues for the continued vitality and essential role of public institutions in a thriving society. Meanwhile, Landau relies extensively on private actors, both market and nonmarket, to build privacy and security measures to protect users from both other market actors and nation-states. Estrin and Juels, by contrast, emphasize the consistent tensions that technical solutions alone create, and challenge us to design mixed legal, technical, and ethical frameworks to achieve a privacy characterized by what media analyst and computer scientist Helen Nissenbaum has called "contextual integrity." Understanding the role of public institutions and values in shaping the privately owned open spaces of the Internet will continue to be a major challenge in the coming years.

Actionable data. Several of the essays raise the prospect of increasingly actionable data becoming the core utility of the Internet. For the Internet of Things, it is easy to see. Data is no longer merely for monitoring, it is also applied for automatic control of the behavior of connected devices. Who owns these data and how they are secured so that unauthorized actors do not have the capac-

ity to act maliciously from a distance are central to the questions of security, privacy, and control throughout the issue. No less important, a mixture of data-analysis techniques and the personalized data available from Internet use today makes data about individuals actionable. Estrin and Juels seek to make small data actionable for individuals, and for their benefit. Tufekci examines how platforms combine data, behavioral sciences, and platform algorithms to predict and manipulate users' actions, perceptions, and emotions. Landau explores how users can protect themselves from being monitored and even acted against based on acquired data.

The influence of advertising. As both Clark and Tufekci emphasize, several of the core utilities of the Internet – Google and Facebook most prominently – depend on advertising to fund their operations. As a result, these advertising-supported services are developing the model of widespread surveillance and the use of actionable data to shape the Internet experience of their users, thereby increasing targeted purchasing. Many of the core tensions around privacy and between public and private values are a function of the fact that consumers demand "free" services, which providers develop and support only through the sale of user information to advertisers. As long as these core Internet utilities are privately provided and depend on advertising, the pressures on privacy and the tensions between providers and users will remain. Unless we find a way to allow users to pay for these utilities, this tension will remain at the core of design choices about how services are delivered, how much autonomy users have, and how much providers will be able to control and monetize the behavior of users.

The Internet started its life as public infrastructure, largely dedicated to communications among academic and public institutions. Over time, it turned into the core communications and information infrastructure of a networked economy and society. And it is now rapidly developing as a control system and organizational platform for the physical environment, through the Internet of Things, and is becoming ever more tightly integrated with the daily flow of life for individuals through mobile and wearable computing. In these transitions, it has become increasingly privately owned, commercial, productive, creative, and dangerous. It has become indispensable to an ever growing range of human activity. Understanding the design challenges these changes pose, subjecting them to continuous critical reflection informed by real-world analysis of the rapidly changing character of the Internet, and insisting on open, rational, democratic debate over the implications of our choices is perhaps the most important role of academic reflection about the past and future Internet.

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