

TECHNOLOGY AND SOCIETY

Avoiding a Cliff Dive

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The image on the cover of Jonathan Zittrain's *The Future of the Internet: And How to Stop It* depicts train tracks that fork at the edge of a cliff. One branch falls off a cliff to the left; the other heads off safely into the distance. Like the artwork, this compelling book starkly presents an impending decision: essentially the choice (of grand social consequence) between two futures for the Internet and the information, computing, and communications ecosystem it has generated. Zittrain (a professor at Harvard Law School) contends that we are approaching rapidly the junction where a choice—really, a series of choices—must be made. And there are many obstacles to choosing the path to salvation. We need to recognize that we are on the train and see where it is heading. We next need to identify the correct path, and then we must make the appropriate decisions that will allow us to follow it. Failure to do so means heading off the side of a cliff to our doom. Though perhaps a bit exaggerated, Zittrain's framing is powerful.

A prominent feature of his framing, repeated throughout the book, is the dichotomy between generative and sterile technologies. At the outset, Zittrain uses two technologies developed by Apple to illustrate this idea. First, he describes the Apple II personal computer as a “quintessentially generative technology” because it was a “platform,” it “invited people to tinker with it,” “Jobs (and Apple) had no clue how the machine would be used,” it was “designed for surprises,” and fortunately, nothing constrained the personal computer to the “hunches of the founders.” At the opposite extreme, he tells us, is the Apple iPhone, which is “sterile” because it “comes preprogrammed”; is not a platform for user innovation; its “functionality is locked in”; and only Apple-authorized innovation is permitted.

Zittrain defines generativity as “a system's capacity to produce unanticipated change through unfiltered contributions from broad and varied audiences.” He elaborates on the concept and outlines five factors (leverage,

adaptability, ease of mastery, accessibility, and transferability) that indicate whether a technology or system is more or less generative. Over the course of the book, he uses the term as an adjective for technologies, systems, human behaviors, tools, and much more. It

seems to encompass (and to some degree, conflate) a number of characteristics studied by scholars of technological innovation, including the degree to which something is open or closed (in terms of access and conditions on use),

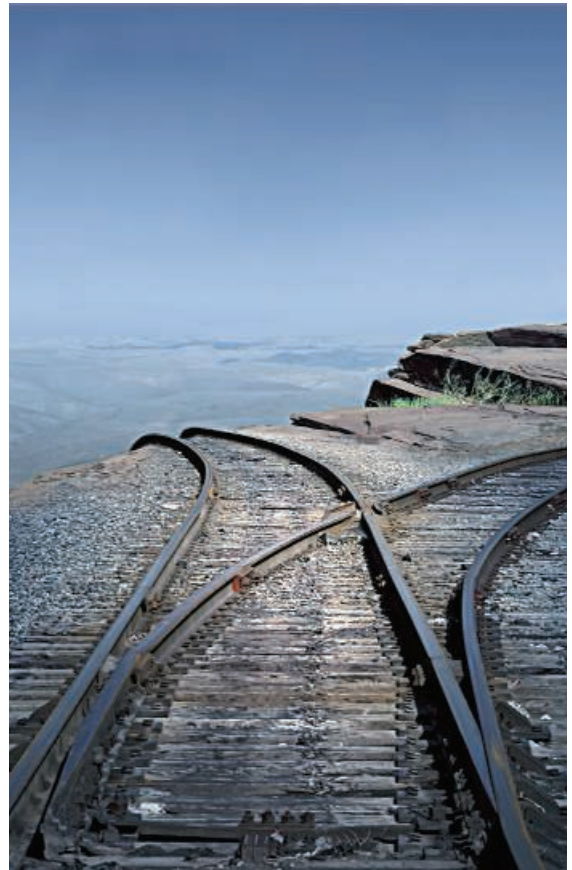
the degree to which something is general or special purpose (in terms of functionality or utility), whether innovation is centralized or decentralized, ease of use, and design complexity. Nonetheless, the generative-sterile dichotomy works well; it focuses the reader's attention acutely on a key functional attribute: openness to innovation by users (2).

The author uses his description of the differences between the Apple II and the iPhone to set up his predictions about the future of the Internet:

In the arc from the Apple II to the iPhone, we learn something important about where the Internet has been, and something more important about where it is going. The PC revolution was launched with PCs that invited innovation by others. So too with the Internet. Both were generative: they were designed to accept any contribution that followed a basic set of rules (either coded for a particular operating system, or respecting the protocols of the Internet). Both overwhelmed their respective proprietary, non-generative competitors, such as the makers of stand-alone word processors and proprietary online services like CompuServe and AOL. But the future unfolding right now is very different from this past. The future is not one of generative PCs attached to a generative network. It is instead one of sterile appliances tethered to a network of control.

**The Future of the Internet
And How to Stop It**
by Jonathan L. Zittrain

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Critically, Zittrain puts the personal computer front and center. This is a substantial contribution to the debate about the future of the Internet. Oddly, scholars and policy-makers have all but ignored the importance of the personal computer. “Too often, a discussion of the Internet and its future stops just short of its endpoints, focusing only on the literal network itself: how many people are connected, whether and how it is filtered, and how fast it carries data. These are important questions, but they risk obscuring the reality that people's experiences with the Internet are shaped at least as much by the devices they use to access it.” [On filtering, another important issue of network access and quality, see (3).] The personal computer is a general-purpose technology that has served us incredibly well as the key platform for software utilization and innovation and as the primary device people use to communicate on the Internet. Economists have recognized the importance of general-purpose technologies (such as the personal computer) and infrastructure (such as the Internet) for economic development and growth. [The exact relationships between general-purpose technologies, infrastructure, and economic growth are subjects of intense study within economics; see, for example, (4, 5).] To fully grapple with many difficult issues and to

better account for the potential long-term consequences, we need to consider more carefully what the future may hold for the personal computer and the Internet in tandem.

Simply put, Zittrain's thesis is that although the Internet and personal computer are generative, both are at risk of becoming sterile. Paradoxically, the reason why both are at risk is their generativity. The very openness to unanticipated, unfiltered changes and innovation gives rise to the pressures for more controlled environments. A generative system does not mean that all changes or innovations will be good. Quite to the contrary, malicious spyware and computer viruses ("bad code"), among many other nasty things, emerge and proliferate alongside the beneficial innovations fostered in the uncontrolled and chaotic environment of generative personal computers and a generative Internet. Furthermore, the more visible, salient, and disruptive the bad code is, the less consumers and businesses appreciate the good and tolerate the chaos from which it came.

As such, for Zittrain the evolution of the Internet to a "network of control" and of personal computers to sterile appliances is underway. The former is seen in the current battle over network neutrality; the latter, in the proliferation of various "locked-down" end-user devices, which he calls "information appliances" (such as "mobile phones, video game consoles, TiVos, iPods, and BlackBerries"). Because consumers often are ill-equipped to deal with most of the harmful stuff—and, in fact, are often to blame because of "their own surfing or program installation choices"—they will increasingly look for gatekeeping, security, and regulation in the devices, technologies, and services they purchase. To better satisfy this demand and also enable devices to "call home" for updates, the appliances may be "tethered" to their suppliers by an Internet connection. This shift sterilizes the Internet and the personal computer, ostensibly at the consumer's request.

Yet Zittrain contends that even though sterilization might be responsive to consumer demand for a more stable and secure computing environment and prioritized services, it is undesirable. He offers three arguments to support this contention: The loss of generativity would affect innovation. Tethered appliances coupled with a network of control dramatically increase regulation of end-user behavior (by government and companies). And, based on his detailed discussion of Wikipedia, he suggests that generativity supports widespread participation and cooperation in cultural production and governance.

Zittrain's arguments that we ought to preserve generative personal computers and the generative Internet are provocative but seem incomplete. He recognizes that there would be opportunity costs but does not fully explain why generativity is worth preserving despite these costs. He does not engage in a structured analysis of the tradeoffs. His appeal to innovation, for example, seems insufficient because he makes no specific theoretic or empirical claims about the quality or quantity of innovation under different degrees of generativity. Such claims could and should be developed but, in fairness, require considerably more work (6). Zittrain's argument about increased regulation of user behavior is powerful, but it depends on his prediction of a complete shift to tethered appliances and controlled networks. To the extent that alternatives persist or hybrid scenarios emerge, it is not clear that his worst fears would materialize. (Of course, this means that sustaining alternatives is important.) Finally, with respect to his third argument, the relationship between generativity and participation and cooperation seems somewhat circular or, at least, underspecified (7). Though incomplete, these arguments merit serious attention and further development.

Zittrain make a number of recommendations about how to avoid heading off the cliff. One interesting suggestion involves porting and reconfiguring tools used at the content layer to encourage collective action—of the sort employed by Wikipedia and eBay, for example—to solve "bad code" problems and bring some stability to the Internet. That is, empower users to become part of the solution. Zittrain discusses a project he is involved with called StopBadware that is "designed to assist rank-and-file Internet users in identifying and avoiding bad code." The project allows users to contribute data about code running on their personal computers and potentially identify and mitigate security threats collectively. He also discusses a partnership between Google and StopBadware that identifies Web sites that have malicious code hidden in them and provides a warning to users in their search results. These are promising and innovative steps.

Whether these and the other prescriptions Zittrain discusses are necessary (or sufficient) to avoid a cliff dive is probably beside the point. The future of the Internet cannot be stopped, and it is unlikely to be either of the two extremes the author describes. He acknowledges this and begins to consider emergent hybrids that may involve the best or worst of the extremes. Most important, *The*

Future of the Internet identifies and analyzes many of the key issues, obstacles, and tradeoffs that will define our future.

References and Notes

1. The book can be read and commented on at <http://lyupnet.org/zittrain/>.
2. There is a rich literature on user innovation, e.g., E. von Hippel, *Democratizing Innovation* (MIT Press, Cambridge, MA, 2005).
3. R. Deibert, J. Palfrey, R. Rohozinski, J. Zittrain, Eds., *Access Denied: The Practice and Policy of Global Internet Filtering* (MIT Press, Cambridge, MA, 2008).
4. T. Bresnahan, M. Trajtenberg, *J. Economet.* **65**, 83 (1995).
5. P. Aghion, P. Howitt, *Endogenous Growth Theory* (MIT Press, Cambridge, MA, 1998).
6. This is a complex task. At either extreme, or anywhere in between, on the generativity scale (assuming such a scale could be constructed), innovation will occur; we should expect different profiles of investments, participants, objectives and motivations, innovations, and so on. Society might value the type of innovation that results from generative systems, but to what degree? At what cost? Compared to what? Etc. Zittrain does a good job of setting the stage for these questions.
7. For a recent examination of how the Internet enables user participation and cooperation in a variety of contexts and why encouraging such activities is socially valuable, see Y. Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (Yale Univ. Press, New Haven, CT, 2006); reviewed by B. Frischmann, *Univ. Chicago Law Rev.* **74**, 1083 (2007).

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GENETICS

Thoughts on Humane Genetics

Robert Pollack

Archibald Garrod, M.D., opened the field of medical genetics with his 1902 *Lancet* article, "The incidence of Alkaptonuria: A study in chemical individuality" (1). He first reported that the offspring of cousins expressed the phenotype of this genetic variant at a high frequency. From there, he leaped to the testable predictions that humans, like Mendel's peas, inherited this chemical difference as a pair of discrete "Mendelian characters" and that both parents had to contribute the variant "character" for the offspring to show the difference. Garrod saw even further than what we would call a recessive phenotype: he closed his paper with the insight that genetic variation of chemical structures from one person to another might explain the differences among us in many—perhaps all—other aspects of our appearance and behavior. His

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