Techné: Research in Philosophy and Technology ISSN: 1091-8264
19:1 (Winter 2015): 26–49 DOI: 10.5840/techne201531926

Wicked Interactions: (On the Necessity of) Reframing the 'Computer' in Philosophy and Design

Heather Wiltse, Erik Stolterman, and Johan Redström

Abstract: The digital computational technologies that over the past decades have come to be fully integrated into nearly all aspects of human life have varying forms, scales, interactive mechanisms, functions, configurations, and interconnections. Much of this complexity and associated implications for human experience are, however, hidden by prevalent notions of 'the computer' as an object. In this paper, we consider how everyday digital technologies collectively mediate human experience, arguing that these technologies are better understood as fluid assemblages that have as many similarities with the infra-structural as they have properties typical for objects. We characterize these aspects in terms of 'wicked interactions,' drawing on and adapting the classic theory of wicked problems in design discourse that has similarly considered the complexity of interactions with and within other types of social infrastructure. In doing this we emphasize the need and the potential for building up connections between philosophy of technology and design discourse, with the hope that this might further the shared goals of understanding digital technologies and their consequences and determining how to act in relation to them and their design.

Key words: digital, design theory, experience, interaction, infrastructure, fluid assemblages

1. Introduction

Digital technologies have come to play a significant role in shaping the character of everyday experience and society. Understanding these technologies and their role is thus an important challenge for both design and philosophy. For design, there is a need to understand digital technologies, since they are now key materials

---

Heather Wiltse, Umeå Institute of Design, Umeå University, SE-901 87 Umeå, Sweden; http://heatherwiltse.me/; heather.wiltse@umu.se; Erik Stolterman, School of Informatics and Computing, Indiana University, 919 East Tenth Street, Bloomington IN 47408; estolter@indiana.edu; Johan Redström, Umeå Institute of Design, Umeå University, SE-901 87 Umeå, Sweden; johan.redstrom@umu.se

used in the design of everyday things and environments; and there is a need to understand existing sociotechnical landscapes that form infrastructures that are both the contexts and sites of design interventions. On the other hand, the field of philosophy of technology addresses three major questions: "(1) What is technology? (2) How can the consequences of technology for society and the human condition be understood and evaluated? (3) How ought we to act in relation to technology?" (Brey 2010). The first two of these basic questions thus parallel general concerns for technology design, while the third explicitly articulates a designerly orientation of acting in the world with the intention of making it better (Nelson and Stolterman 2012). Given these shared concerns, and the prevalent desire within philosophy of technology to inform design (e.g., Verbeek 2005, 2011; Dorrestijn 2012; Kiran 2012) it would seem productive to consider design philosophy and philosophy of technology in tandem in order to both reveal and build up shared theoretical foundations. Indeed, we believe that the account of digital technologies necessary for analyzing their role in contemporary life will require such disciplinary combinations.

Digital technologies[1] present an important and unique challenge for both design and philosophy. The computational technologies that have come to be integrated into all aspects of life have varying forms, scales, interactive mechanisms, functions, configurations, and interconnections. They may be intentionally used as tools, or blend into the background as part of environments. Their functionality may be defined by the capabilities of a stand-alone device, but is now perhaps more typically a function of their connections to other underlying technological infrastructures (such as the Internet or GPS systems) and platforms that support a variety of interconnected applications and services. In the case of these networked digital technologies the locus of activity is thus frequently not the device itself, but rather the larger platforms and associated data flows for which the device is only one of many access points.

However, despite this situation, the notion of the 'computer' as a distinct and analytically unproblematic object is remarkably resilient. Human-computer interaction (HCI), the field that has historically been most directly engaged with the development of computational technologies as they interact with humans, has over its history re-conceptualized and re-imagined its own task and object of study in relation to changing conceptions of the 'user'; but it has not yet similarly problematized the 'computer' as an object that requires intentional framing and study. There are of course several attempts at capturing digital technology as something more than just a computer sitting on a desk; for instance, ubiquitous, ambient, and pervasive computing and concepts such as the ‘invisible computer’ (Norman 1999) all point to a recognition that the traditional understanding of the ‘computer’ needs to be changed. There is also not yet well-developed theory of the digital (particularly the networked digital) as the material that is both used in interaction design practice and that comes to constitute our hybrid digital/physical environments (Wiltse 2013).

A similar situation can be seen within philosophy of technology. Classic theories of technology were developed to speak to technologies of the modern or even primitive eras; and while they are still relevant and useful in many ways, they also do not account for or make visible much that is distinctive and significant about the digital. Further, even addressing the full spectrum of interconnected digital technologies under broad headings such as ‘computers,’ ‘emerging technologies,’ ‘ICTs,’ or ‘media’ leads to overlooking the very details that have a huge impact in shaping the many and varied things that these technologies actually do.

In this paper we attempt to intervene in this situation, with the purpose of outlining how everyday digital technologies collectively mediate human experience. To arrive at such an account, we need to do several things: 1) to problematize the ‘computer’ as an object of study and design; 2) to begin to develop a theoretical perspective appropriate for dealing with modern digital technologies; 3) to do some theoretical bridge-building between design philosophy and philosophy of technology around some shared issues and concerns. It is our hope that such shared theoretical foundations and language might also do some practical work of scaffolding ongoing conversations between philosophy of technology and design discourse.

Our basic theoretical orientation here is postphenomenological, and our primary concern is how human action and experience unfold as we come to live with digital technologies turned infrastructural. However, to articulate and understand the complex social implications that these technologies cause, we need to go further into the structure of the object than what is perhaps customary in postphenomenology. As we will argue below, the reason is that we are in this case not dealing with technologies that can be captured analytically in accounts of stable, or even multi-stable, ‘objects.’ On the contrary, these technologies must be understood as fluid assemblages.

Indeed, the very term ‘infrastructural’ is a guide: the technologies we address here have many of their significant structural properties below the surface so to speak. Much of what it means to use and live with them is not visible at the surface of interaction. Of course many complex technologies have an internal complexity that is not necessarily at all readily present before human perception and action (Janlert and Stolterman 2010); but, as we will try to illustrate in the examples and our theoretical analysis that will follow, what we are dealing with here is something slightly different. This is not just a matter of an internal complexity but a matter of *a new kind of interconnectedness* between the technical and the social caused by massively networked digital technologies. Thus, while it at times might seem as if we stray from the phenomenological and into the technical, it is because of the fact that we are now dealing with the infra-structural and therefore need to unpack these interactions among humans and technologies not just on the surface (where the literal human-computer interaction takes place), but also deeper down.

2. Agenda

We begin our enterprise by first developing the argument that, in relation to human experience, 'computers' have been under-theorized, and that the prevailing object-based understanding[2] is not sufficient for addressing contemporary digital technologies. We next note a historical parallel between the complexity of interactions with, within, around, between, and through these technologies and that of the kinds of social dynamics that design researchers have described as 'wicked problems.' We revisit this theory of wicked problems and, positioning interactive technologies as yet another type of social infrastructure that serves as the context and site for design interventions, develop the concept of *wicked interactions*. Finally, we use this concept to unpack the 'computer,' and suggest that wicked interactions can serve as a conceptual frame that is capable of replacing an object-based understanding of 'computers' and enabling intentional framing and analysis that is suitable for modern digital technologies. This new theoretical perspective could potentially also provide a useful framework and common language that could support productive conversations between design and philosophy. We conclude with some reflections on the way forward for building up common ground and facilitating a productive dialogue between design philosophy and the philosophy of technology.

3. The Under-Theorization of the 'Computer'

When considering the notion of the 'computer,' there are perhaps a couple main trajectories that are commonly followed in trying to understand and articulate what it is. The first is based on viewing it as an 'artifact' with certain physical and functional properties, and clearly identifiable, concrete presence in the world. The second is based on understanding it as a 'system.' The connotations of 'system' are traditionally more diverse, with most definitions treating it as something that always has relations to other systems and must be intentionally defined and framed in some way for analysis.

Another commonly used notion is 'technology,' which in computer science tends to refer to the functional aspects of hardware and software systems. This is also the nominal subject of philosophy of technology, and the rather thorny history of the term in this context is also illuminating here. Early philosophical consideration of the tools and machines of modern life tended to consider Technology (with a capital T) as a totalizing and monolithic force that entailed certain forms of social organization and dictated certain ways of being in and taking up with the world (e.g., Mumford 2010; Ellul 1964; Marcuse 1991; Heidegger 1977). The more recent 'empirical turn' (Achterhuis 2001) in philosophy of technology has been guided by the recognition that such sweeping and general approaches are not adequate when trying to account for the many and varied things that technologies actually do (Verbeek 2005). We are here continuing this trajectory of attempting to open up and consider technologies more precisely by exploring the kinds of 'opening up' that are required when dealing with the digital.

None of these commonly used notions can be seen as a result of serious theorizing; instead they resonate with a more intuitive everyday understanding of the concept. However, this does not mean that these notions are not changing or evolving. We will take a closer look at how this change and evolution has occurred in the fields of human-computer interaction and philosophy of technology.

3.1 Conceptions in Human-Computer Interaction

Human-computer interaction (HCI) has throughout its history reconceptualized and reimagined its task and corresponding object of study in response to new challenges and technological developments. New conceptions and paradigms have led to shifts in the focus and goals of research and practice. As Bannon (2011) states, this history of calls to reimagine HCI has taken it from human factors—trying to fit humans to machines—to early user-centered HCI to interaction design. Bannon himself goes on to argue for a new 'human-centered design' that focuses on the experience of users, an enterprise that characterizes "third-wave HCI" (Bødker 2006).

In addition to changing the scope of the variables considered in literal human-computer interaction (from usability to experience), the scope of the *context* considered has changed as well. This ongoing shift was famously described by

Grudin in 1990 as the 'computer reaching out' into organizations and even the world at large.

It is possible to see the developments that Bannon and Grudin identify as a continuous broadening and refining of the notion of what 'human' (and 'user') stands for in 'human-computer interaction.' That is to say, focus has shifted from cognitive and behavioral aspects to the full richness of human experience, and from a single person in a defined (typically professional) role to complex everyday social settings and processes. However, the 'computer' has not been similarly problematized and expanded, even as computational technologies have undergone enormous changes in their capabilities, materials, sizes, forms, and configurations. Computational technologies are still generally understood as the stable given, while the human is problematized.

There are possibly a couple lines of development responsible for the current situation. The first one is that the field of computer science, the main context of much of this research, is traditionally essentially technology-driven. Technological innovation drives the field, and the role of human experience has been primarily an issue of effectiveness and efficiency, as use becomes a factor that needs to be addressed. The term 'human factors' is indicative of this perspective. The second line of research leading up to this perspective is that much of the human side of this field has its roots in the behavioral sciences. Also in this case, the computer becomes that which is 'given,' as experimental studies are typically set up around questions of how people use and understand given designs. Taken together, these traditions historically bring a strong focus on the technical rather than the experiential aspects of computers and what it is to use them—and while much has been done to expand the scope beyond such restricted perspectives, their influence can still be traced in a relatively under-developed conceptual critique of foundational notions such as 'the computer.'

Moreover, the digital has not yet been theorized in a robust way as a material basis for design in general and for its impact on the character and structure of everyday interactions in particular. Although there is currently a great interest in considering the nature and possibilities of digital materials (e.g., Redström 2005; Dourish and Mazmanian 2013; Sundström et al. 2011; Sundström and Höök 2010; Fernaeus and Sundström 2012; Jung and Stolterman 2012; Wiberg and Robles 2010), this research tends to be concerned primarily with considering opportunities for interaction at a material level. However, digital materials that come to exist in the world as part of our hybrid digital/physical environments can also, like physical materials, shape possibilities for (inter)action and make activities visible (Wiltse and Stolterman 2010, Wiltse 2013). There thus seems to be a need to consider the role and capabilities of digital materials/technologies from a phenomenological perspective that is attuned to broader issues of human experience. For this task, it makes sense to turn to philosophy of technology.

3.2 Conceptions in Philosophy of Technology

Philosophy of technology has a long tradition of thinking analytically and critically about technologies, their character, and consequences for human activity and experience. More recent work in particular is also quite artifact-centered (e.g., Harman 2009; Verbeek 2005, 2011; Dorrestijn 2012), which seems to afford the possibility for a promising dialogue between HCI and philosophy of technology. Fallman (2011) has also directly suggested drawing on the philosophy of technology in order to think about the 'good' that is pursued through interaction design. There has also been related work done in science and technology studies (STS) which has troubled presentist assumptions about technologies and placed them within broader historical and social contexts (e.g., Bijker, Hughes, and Pinch 1987; MacKenzie 1996; Akrich 1991; Latour 1999, 2005).

However, the technologies that have typically been grappled with under the heading of philosophy of technology (and STS) are primarily those of the modern industrial era: things like hydroelectric plants (Heidegger 1977), hammers (Heidegger 2010), bicycles (Feenberg 1999), eye glasses (Ihde 1990), bridges (Winner 1986), and central heating units (Borgmann 1984). More recently, the philosophy of technology has also looked at the technological tools used in technoscientific and medical praxis (Verbeek 2008, 2011; Hasse 2008; Rosenberger 2013). In contrast, the digital technologies that permeate our everyday lives—things like emails, smart phones, social networking platforms, blogs, and instant messages—have from philosophy of technology received relatively less attention. Of course all of these 'older' and more specialized technologies are still with us and remain worthy of attention. Yet relatively more novel, digital, interactive, networked technologies also play a large role in shaping the character of our everyday lives, and the ways in which we take up with the world. Moreover, since moving toward digitization seems to entail an increasing dissociation between technology's matter, form, and function (Kallinikos 2013), there is a need to develop correspondingly fine-grained analytic approaches capable of sorting out this relatively new kind of ontological complexity.

Focusing analytical and critical effort on 'new and emerging' technologies (Brey 2012; Wittkower, Selinger, and Rush 2013) or broad constructs like computers, ICTs, or media leaves out or does not sufficiently bring into focus the enormous variety of applications that are possible to create through using digital technologies, as well as significant technologically-textured and technologically-mediated aspects of contemporary human experience. There is a need to not only assess specialized technologies and uses, but to also critically examine small, everyday digital technologies and the digital infrastructures that they constitute and upon which they rely.

4. Considering Digital Interactions

In order to foreground some of the qualities and characteristics of contemporary digital technologies, as well as interactions with and through them, it will be helpful to start with a few simple examples.

4.1 Retweeting

Consider some of the interactions involved in the case of a person who views and then retweets a link to a news article on Twitter. From a phenomenological perspective, in seeing the original tweet she also perceives its sender (perhaps a friend or professional acquaintance) viewing the article and then tweeting about it at a particular moment in time. When she views the news article she will likely see, in addition to the main content, social media sharing buttons that indicate how many times they have been used to share this article, allowing her to also get a sense for how many other people have also viewed it and thought it was worth sharing. When she retweets this she registers her own presence and her activity of checking her Twitter account, (probably) viewing this article, and then retweeting the link, as well as the fact the she follows or otherwise came to view the account of the person who authored the original tweet. This tweet may be seen by her followers fairly soon, but it will also (unless deleted) remain in her Twitter profile so that it can be viewed much later. If it includes a hashtag, it will also show up when someone searches for that term. Since the link was probably shortened through a service like Bitly,[3] it will also, if she is in the United States, show up on its real-time map of link clicks,[4] as well as be factored into the analytic data that is viewable on the back end for whoever created the link.[5] If the tweet referenced a brand name, it will also likely show up in the social media monitoring platform used by the marketing and communications personnel for that brand. If her Twitter account is linked to her Facebook account, the tweet may be automatically posted there as well, and may influence the advertising content she later sees there.

In this example, the ‘technology’ or ‘computer’ involved in a retweet could be seen as including at least the devices used, the Twitter platform and API, Twitter clients, the article website, hashtags (a hybrid of a social practice and technology developed to support it), the Bitly link shortening platform, the Internet, Internet service providers, network connections (e.g., wifi, cellular data), Twitter servers, social media monitoring platforms, the Facebook platform, and the Twitter Facebook app. In this example there is no simple *unit* that incorporates all these aspects in something that we can simply denote as the ‘computer.’ There is no easily distinguished artifact, object or system that in some common sense way would be obvious as the technological artifact in question.

4.2 Songza iPhone App

When listening to music on the Songza iOS app,[6] the interaction between person and app is fairly simple: pick a mood or activity, then pick a specific playlist from one of the available categories, then listen. But there are also people who have different relationships to Songza through other sides of the technology, such as the music industry experts who curate the playlists, perhaps on behalf of a specific featured record label. There are also the advertisers who utilize the Songza platform in order to deliver their content. As the advertising information on the Songza website explains:

> Songza enables advertisers to reach the right users at the right time based on exactly what the user is doing at that moment. Whether users are working out, cleaning or just relaxing at home, Songza guides them to the perfect, expertly-curated playlist to make their experience better. Advertisers can leverage the Songza platform to create lifestyle-enhancing experiences for customers that pair the perfect products to the perfect moment.[7]

The page goes on to explain how this content can be delivered: “Songza can deliver your brand’s message through Native Advertising solutions as well as Pre-Roll Video, Pre-Roll Type-In Ads, IAB Rising Star units and traditional media placements across mobile and desktop.” Each of these advertising types is also its own little universe, such as the IAB Rising Star system that has, only in the mobile category, formats of IAB Mobile Filmstrip, IAB Mobile Pull, IAB Mobile Adhesion Banner, IAB Mobile Full Page Flex, and IAB Mobile Slider, each with its own technical specifications.[8]

The 'traditional media placements' seem to include the Apple iAd platform for delivering ad content, which is also very precisely targeted based on user activity data. As Apple explains on their advertiser-facing information page:

> Precision ad targeting is key not only to the success of your campaign, but also to the experience of our users. Somewhere within our nearly 600 million iTunes accounts is the exact group of people you want to reach. You can use our audience insights to understand what they care about so that your message will resonate. Our targeting is built upon a foundation of registration and media consumption data that's exclusive to iAd. Whether you need specialized insights around their lifestyle, purchase habits, or want to reach your own customers, we've got you covered.[9]

Again, the example shows that not even what constitutes an app, in this case Songza, is easily framed and identifiable. The technological complexity of this simple app becomes apparent when we look behind the screen.

4.3 Facebook

One 'technology' that has become practically ubiquitous is Facebook. For many, it is a central hub of social life, facilitating social interaction, content sharing, and event planning, among other things. It is a big part of how many people keep track of what is going on in their social worlds. It has also become an important platform for brand building, content delivery and promotion, and targeted marketing. A Facebook account can also be used for account creation and authentication on other sites. As it has become both technically and socially embedded in everyday life, it is in itself an infrastructure of significant scope and scale.

Since Facebook is based on or commonly manifested as a website, it might seem at first glance to fall more naturally under the heading of media. After all, it is a channel for communication and sharing of media content (photos, videos, web links, etc.) with an audience (friends). However, it is also much more than that: it is something that mediates social awareness and interaction. From a phenomenological perspective it is more of a social space than a media channel allowing producers to push content to consumers. It is also highly interconnected with social happenings in the physical world, with interactions frequently crossing over between the physical and 'virtual.' This can be clearly seen in the case of Facebook 'events' that correspond to real-world events, for example.

Facebook might also be considered as software or as a web application. It is less clear if it can be seen as hardware, and for this reason also it might not for some count as technology (although its massive server clusters certainly have their own materiality). And yet once again because it can serve in this capacity of mediating awareness and engagement with one's (social) world, it seems appropriate to approach it as technology in its own right.

Yet Facebook is also not simply a technology, and could perhaps be better seen as a platform with a number of components and functions. There are apps created by many different developers that allow for many more types of activities and interactions than the basic status updates that constitute what might be seen as Facebook's core functionality. In addition to the 'user' side of Facebook, there is also the highly significant 'advertiser' side in which marketers utilize the platform to deliver highly-targeted advertising content to specific kinds of users who are identified by their online activities. As a record of people's activities, it is also a site of surveillance and data gathering by not only Facebook and marketers but also government agencies like the NSA in the United States (Greenwald and MacAskill 2013). Facebook now monitors user activity at the key stroke level, so that they can record even a status update that was typed but then not posted (Golbeck 2013). So even though, from the person's perspective, this update was not registered, Facebook will potentially have a record of this activity that happened at a particular moment in time.

Returning to Facebook proper, it is also interesting how even relatively small changes in functionality change what is or can be made visible and the kinds of interactions that are possible. For example, allowing comments on status updates enabled the creation of conversation spaces that can potentially bring together people who do not know each other but are connected by a mutual friend. The addition of the 'Like' button for posts allowed for a different type of interaction, as did the later change that allowed for 'liking' specific comments. Although these were relatively small changes from a technical perspective, they significantly altered the possibilities and character of Facebook as a social space.

Again, it becomes fairly obvious that Facebook does not easily fit into the traditional 'computer' or even application notions. It is a multifaceted conglomerate of technologies that can be approached and defined in an infinite number of ways.

4.4 Issues with Digital Interactions

When interactions such as the examples above are unpacked, it becomes clear that even interactions with technologies that are simple and commonplace from the 'user' point of view turn out to be not so simple at all when considering the many layers of digital infrastructures involved and the various viewpoints on interactions that they enable. The fact that all of the infrastructures involved in the examples above are contained in or accessed through a typical smartphone highlights the inadequacy of maintaining a strictly object-based understanding of digital technologies when considering their roles in human experience. It is also worth making a few other general observations about characteristics of digital technologies at this point.

First, the functionality of digital technologies is not defined or confined by physical form. In fact, their capabilities far exceed what might be suggested by the physical presence of a device as an object. The iPhone is a good illustration of this, as it is clear that its primary capabilities stem from what goes on inside and *through* it rather than from its existence as a small, flat, shiny block of glass and aluminum. One way to think about this is to imagine the things that it is possible to do with an iPhone with power versus one without (i.e., if the battery is dead and it is not possible to recharge it). The functionality of digital technologies is also facilitated by interconnected platforms and systems to which devices connect, but which do not exist on the devices themselves. One example of this is the popular Evernote service for managing notes, web clippings, and other media. It might be possible to use only the Evernote iPhone app for creating notes to save and access locally, but a big part of the functionality and utility of Evernote is its capability to capture and sync content on and across various devices. Another example is anything that involves sending or posting a message that will end up being displayed on another Internet-connected device. One way to think about this is to imagine the things that it is possible to do with an iPhone with network connectivity versus one without (i.e., Internet, data, or cellular access).

Second, it is important to recognize the distinction between *human action* and *'computer' action*. In the vignettes above, many of the simple and straightforward interactions that people have with technologies result in fairly complex technical processes being carried out, in many cases behind the scenes; that is, to a user that complexity is almost fully hidden. For example, in terms of human interaction with technology, posting a tweet requires just a few taps and clicks on a digital device. But even this simple human action results in almost innumerable actions on the part of the technologies involved, ranging from those of the operating system that govern the devices' memory, processes, and network capabilities, to those of the local Twitter client, Twitter API and platform, Internet, and the other millions of devices connected to Twitter around the world on which the tweet might show up. Conversely, even though technologies are most typically discussed in terms of how humans use them, it is also increasingly appropriate to consider 'interactions' that originate with technologies and that may not even be visible to the humans involved. For example, a person who posts a tweet will not typically be aware of or even think about the ways in which various surveillance technologies (from those used for brand management purposes to government surveillance) monitor what goes on, and make activities like these show up in contexts far outside of those for which they were originally intended. This dynamic is present whenever technologies are set up to monitor and respond to human action in some way.

Finally, it seems appropriate to reemphasize the often-made point that the ways in which technologies are used and what they end up doing in the world may differ markedly from the uses anticipated and intended during their design. Moreover, while interaction designers may be most interested in the types of interactions that are possible with digital technologies and with the use cases that they can support, the technologies they envision may actually come to have a different character and social function once they are out in the world and participating in broader infrastructures and practices. This is particularly apparent in the case of social media that have come to be sites for government surveillance and marketing, but can be seen in other ways as well.

5. Revisiting Wicked Problems

In the interests of furthering the creation of connections between design discourse and philosophy of technology, we will now turn to an example of how the analysis of digital technologies presented here can be positioned and developed further in a historical context. This historical parallel to follow suggests that our current attempt to unpack the 'computer' is likely to not only challenge our understanding of what constitutes a computational 'object,' but also the way we combine perspectives and disciplines to arrive a better view of the complexity at hand.

From a methodological point of view, design went through significant developments during the late 1950s and 1960s. Interestingly, from our present point of view, is that much of this had to do with difficulties stemming from an earlier understanding of what the 'object' of design is. As design problems grew ever more complex in the wake of urbanization and large-scale industrialization, the need to develop a new understanding of the 'object' of design and corresponding new ways of designing became urgent. In the early 1960s, the so-called 'Design Methods movement' (Cross 1984) introduced a range of new tools and methods to design that above all were about opening up the design process for participation and for the sharing of expertise across domains. The realization that one discipline would not bring all the expertise necessary to address emerging problems such as city planning, social systems, and infrastructures, created a certain interest in how formal and analytical methods could be used by large teams to divide complex problems into smaller and more manageable ones. Herbert Simon presented one of the most elaborate accounts of what this approach implies to our understanding of man-made systems in his seminal work: *The Sciences of the Artificial* (1969).

However, it gradually became clear that these new systems, the expanding urban infrastructures, social welfare systems, etc., generated a complexity that the rational problem-solving approaches developed during the 1960s could not address. Whereas it might seem possible to have an overview of the design of the systems as such, what happens as they become part of everyday life is more typically on the verge of indeterminacy because of the complexity arising as they start to interact with both each other and the world around—the actions and interactions of people included. As a professor in design methodology at HfG Ulm (1958–1963), Horst Rittel was very much at the center of these changes. He formulated the concept of wicked problems in design, suggesting that wicked problems refer to "that class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Churchman 1967). It should be noted that wickedness here does not mean bad or evil, but rather something more akin to challenging or difficult.

Rittel and Webber (1973) later elaborated on this. Their starting point was in problems of social planning. They recognized that social processes are not isolated, but are rather always part of much larger systems, which are themselves interconnected with other networks of systems. Action in any part of a system can have consequences in other parts of the system or even other systems. This also means that these kinds of social problems are fundamentally different from the problems that science has successfully addressed, which, in the language of Rittel and Webber, can be considered 'tame.' Although they may be very difficult, scientific 'tame' problems can ideally be constrained by definite parameters, and have solutions that are arrived at and evaluated by methods widely recognized as appropriate for the task. Donald Schön famously labeled such an approach as based on a 'technical rationality.' He further critically argued that such a rationality, while successful at dealing with formal and well-defined problems, is not suitable for dealing with real world problems (Schön 1983).

Now, let us turn to the actual concept of 'wicked problems' and how they were described. Wicked problems are, according to Rittel and Webber (1973), infinitely messy and complex, and possess the following characteristics that distinguish them from tame ones:

1. Wicked problems have no definitive formulation.
2. They do not have a stopping rule.
3. Their solutions can be good or bad, but never true or false.
4. There is no final test of a solution to a wicked problem, and no test can be applied right away.
5. Every attempt at solving a wicked problem has significant consequences: wicked problems do not allow for trial and error.
6. There is no set of valid operations or solutions to a wicked problem.
7. Wicked problems are all fundamentally unique.
8. Wicked problems are all symptoms of other, higher-level problems.
9. Wicked problems can be described in many different ways, with each description being determined by the lifeworld of the analyst and implying different solutions.
10. Those who address wicked problems have no right to be wrong, and are held fully accountable for their actions.

The fundamental aspect of wicked problems is their indeterminacy: they do not have any definitive conditions or limits (Buchanan 1992). Further, they are not just difficult—they are fundamentally impossible to solve. The only thing that may be done is to choose a course of action that seems preferable to some chosen 'client' or user. Most problems in the everyday real world can be characterized as wicked. Designers must find ways to navigate these ill-defined problem spaces and ways to act in spite of and taking into account their wickedness. This skill has been seen as being at the heart of design thinking and as a core characteristic of a designerly approach (Cross 2001; Nelson and Stolterman 2012).

The systems that generated these wicked problems that Rittel studied are not entirely unlike what we could see in the vignettes above. In fact, it is quite reasonable to now think of the 'computer' as yet another system in this family of infrastructures. Indeed, even very early accounts of 'ubiquitous computing' are filled with references to such infrastructures, such as that computing power will be as easily available as electrical power (Weiser 1991). And so let us try to use some of the key characteristics of wicked problems to describe the interactions resulting from contemporary computational (infra)structures.

6. Wicked Interactions

Drawing on the classic definition of wicked problems described above, we can outline parallel characteristics of *wicked interactions* with and within computational (infra)structures:

1. Wicked interactions have no definitive description.
2. Wicked interactions are continuously unfolding, sometimes in completely new directions.
3. Every attempt at defining or delimiting the scope of a wicked interaction has significant consequences: wicked interactions do not allow for trial and error.
4. There is no one set of valid design methods or solutions to the design of something that becomes part of wicked interactions.
5. Wicked interactions are all fundamentally unique.
6. Wicked interactions are all related to other, higher-level interactions.
7. Wicked interactions can be described in many different ways, with each description being determined by the lifeworld of the analyst and implying different design responses.
8. Those who create designs giving rise to wicked interactions have no right to be wrong, and are held fully accountable for their actions.

Returning to our previous illustrations of how the concept of an 'object' is problematic as a starting point for articulating the experiences associated with things such as a retweet, let us reformulate a couple of the characteristics of wicked problems and describe the wicked interactions that seem to occur.

If we start with reformulating the first characteristic to say that 'wicked interactions have no definitive description,' we can clearly see how it applies also to the act of retweeting. While the typical description of this interaction and associated experience might be based on aspects such as viewing the tweet itself and options for sharing it further, we might also want to add aspects related to how previous distribution indications turn up in the interface, on occasion effectively becoming suggestions that this is a popular one that the viewer might want to share as well. Expanding the description even further, we might want to include aspects of feedback, e.g., how the original author through the act of retweeting receives further information about its diffusion. Moving even further in our description of what a retweet is, we will at some point end up with the effects of hashtags and how hashtags both allow groups of people to follow a certain stream of content as well as provide an opportunity for companies and other stakeholders to harvest information and monitor what is being communicated in social media. We might see a retweet as a social phenomenon that happens in the context of a person's other tweets and online identities. Or, we might decide to focus our description on the more technical aspects enabling certain social interactions, such as the apps, API's, networks, etc. In short, there is no definitive description of even such a simple thing as a retweet in this context.

If we turn to the second characteristic and reformulate the original statement as 'wicked interactions are continuously unfolding, sometimes in completely new directions,' we can see how this also applies here. Think, for instance, of how Twitter became part of the social interactions unfolding during the 'Arab spring,' and what role aspects of speed and diffusion of retweeting might have played in this. That this particular technology would be used in this way is most likely not something its originators anticipated. Or, if we turn to how this technology is used in Business Intelligence[10] for monitoring, we can think of how a simple retweet might also have quite substantial effects on our interactions with other applications: if one's Twitter account is linked to a Facebook account, and if the hashtag used is monitored by a company that then decides to make a bid for the advertisement spots on the Facebook page, the simple retweet might be the starting point for a complex chain of events making up a kind of persuasive process intended to lead to a purchase at a certain online store later. Indeed, both these examples of unfolding interactions, as well as the previous illustration of the lack of definitive descriptions, seem to confirm that also the third characteristic applies here: 'Every attempt at defining or delimiting the scope of a wicked interaction has significant consequences.'

We will now leave it for the reader to continue this inquiry into the relations between this new kind of digital infrastructure and what Rittel and others observed in earlier ones; but we think that at this stage it is already becoming clear that even a simple example such as the retweet offers a social and experiential complexity that is more akin to what has been addressed in theories such as the one on 'wicked problems' than it is to a typical notion of a technical object. This type of technology calls us to acknowledge and respond to its more fluid, unfolding and perhaps also partly unpredictable character—which cannot be done through trying to isolate functions as the basic components of a description or definition (Kroes 2001). As such, we believe that an account articulated around ideas of fluid assemblages rather than solitary objects might be both necessary and productive.

7. Discussion and Implications

The purpose of this inquiry has not been to come up with a (new) definition of a particular technology as part of a (new) analysis of our experience of the same. On the contrary, we have argued that prevalent issues pertaining to the under-theorization of technologies such as the 'computer' calls for a different approach to the making of such definitions altogether. The reason, we argue, is that these digital technologies need to be seen as *fluid assemblages* that are constantly in flux rather than as stable self-contained objects. Therefore, our definitions need a similar fluidity to allow us to follow and frame human interactions and experience as they unfold with and through these technologies.

The character of continuously becoming assemblages suggests one reason why the emerging digital infrastructures, such as the ones accessed through 'computers,' have not been properly theorized: to determine what would be a suitable framing of technology in a particular case here becomes a process that to some extent reverses the commonly held understanding of the scientific process. In much research dominating the study of digital technologies it is usually seen as crucial to establish a clear object of study and associated definitions at the beginning of the research process in order to be able to select relevant and suitable methods and techniques. This is an approach that is adapted from traditionally scientific areas where careful and very precise definitions are key to the successful application of established scientific methods. In the case of these more fluid assemblages, the process in many cases needs to become the reverse.

When we make this reversal, it is possible to see the whole research process as a framing process. The research starts with some assumptions about the relationship between technology and experience. A careful research process that fully respects the complexity resulting from these 'wicked interactions' can then lead to a valid and relevant framing of technology as an *outcome*. So, instead of starting with a clear definition of what the technology 'is,' studies of experience in relation to such digital infrastructures will lead to an understanding of how to frame technology in a way that 'explains' or correlates to certain experiences. This means that working with wicked interactions is not something that is done before the 'real' research takes place. Instead, it means that the whole research effort is to establish a framing of technology that makes sense and enables a clearer understanding. The process of analysis is not only the analysis of an established unit but also the process by which the unit is established.

This, in turn, suggests the possibility of a different relation between philosophy and design: one that is not only about the shared use of analytical results, but that collaboratively deals with the unfolding design of new definitions. This kind of unfolding of new definitions manifests a family resemblance or resonance between the design process and the philosophical process. It may be that design as an activity could learn from philosophy as activity about things like how to approach complex issues, how to define, and how to compare and contrast concrete examples with abstract conceptions. These are all methodological 'tricks' that over centuries have been refined in philosophy and that may be suitable for approaching 'wicked interactions.' On the other hand, the philosophy of technology can learn much from design discourse and its tradition of working closely with both concrete artifacts and complex social systems in order to understand not only what currently is, but also what could be.

8. Conclusion

In this paper we have conducted an inquiry into the character of modern digital technologies in relation to their experiential and social contexts and their design. We have considered the complexities of digital interactions through a set of case studies and, noting their infrastructural aspects and the inadequacy of object-based conceptions, drawn a parallel to classic design theory which has similarly considered the complexities of interactions with and within other kinds of social infrastructures. Using this theory of 'wicked problems' as a basis, we have developed 'wicked interactions' as an account of these infrastructural aspects of digital technologies and an approach to conceptualizing them as fluid assemblages. In doing this we have emphasized the need and the potential for building up connections between philosophy of technology and design discourse, with the hope that this might further the shared goals of understanding digital technologies and their consequences and determining how to act in relation to them and their design.

Notes

1. We here consider digital technologies to include the full range of modern computational technologies and systems, including devices, applications, platforms, programs, protocols, the Internet, and other underlying data infrastructures. Importantly, we also assume that they either are or easily can be networked.

2. The term 'object-based understanding' is used here not in a technical or formal sense, but rather as a general descriptor for research that takes computational devices for granted as a given unit and starting point of analysis. It should be noted that we do not mean to imply that these approaches are inherently bad; indeed, for older technologies in particular this framing made sense. For example, even in the title of Lucy Suchman's seminal and highly influential book *Human-Machine Reconfigurations: Plans and Situated Actions* (2007) it is clear that a starting assumption is that the phenomena of interest are those which take place between the pre-given entities of human and machine. It is also apparent in Donald Norman's equally influential book *The Design of Everyday Things* (1988), which, even though it did not deal explicitly with computational things, provided a framework for much of the early usability research in human-computer interaction. While the copy machines that were Suchman's 'machines' of interest, as well as other relatively basic and standalone computational devices, might in general be adequately addressed through such a framing, we are here arguing that it is no longer sufficient for theorizing contemporary digital technologies due to the ways in which they are qualitatively different (which will be discussed later in the paper).

3. https://bitly.com.

4. https://bitly.com/a/media_map.

5. An overview of Bitly's analytic capabilities, which include tracking people across multiple websites, is available at http://www.enterprise.bitly.com.

6. https://itunes.apple.com/us/app/songza/id453111583?mt=8.

7. http://songza.com/page/advertising/.

8. http://www.iab.net/risingstars#2.

9. http://advertising.apple.com/experience/app-network/.

10. For readers unfamiliar with the term, a helpful description of Business Intelligence can be found at http://en.wikipedia.org/wiki/Business_intelligence.

References

Achterhuis, Hans. (1997) 2001. *American Philosophy of Technology: The Empirical Turn*, trans. Robert P. Crease. Bloomington: Indiana University Press.

Akrich, Madeleine. 1991. "The De-scription of Technical Objects." In *Shaping Technology/Building Society*, ed. Wiebe E. Bijker, 205–24. Cambridge, MA: MIT Press.

Bannon, L. 2011. "Reimagining HCI: Toward a More Human-Centered Perspective." *Interactions* 18(4): 50–57. http://dx.doi.org/10.1145/1978822.1978833

Bijker, Wiebe E., Thomas P. Hughes, and Trevor J. Pinch. 1987. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Bødker, Susanne. 2006. "When Second Wave HCI Meets Third Wave Challenges." In *NordiCHI '06: Proceedings of the 4th Nordic Conference on Human-Computer Interaction*. New York: Association for Computing Machinery, 1–8. http://dx.doi.org/10.1145/1182475.1182476

Borgmann, Albert. 1984. *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Brey, Philip. 2010. "Philosophy of Technology after the Empirical Turn." *Techné: Research in Philosophy and Technology* 14(1): 36–48. http://dx.doi.org/10.5840/techne20101416

Brey, Philip. 2012. "Anticipating Ethical Issues in Emerging IT." *Ethics and Information Technology* 14(4): 305–17. http://dx.doi.org/10.1007/s10676-012-9293-y

Buchanan, Richard. 1992. "Wicked Problems in Design Thinking." *Design Issues* 8(2): 5–21. http://dx.doi.org/10.2307/1511637

Churchman, C. West. 1967. "Wicked Problems." *Management Science* 14(4): 141–42.

Cross, Nigel, ed. 1984. *Developments in Design Methodology*. Chichester: John Wiley & Sons.

Cross, Nigel. 2001. "Designerly Ways of Knowing: Design Discipline versus Design Science." *Design Issues* 17(3): 49–55. http://dx.doi.org/10.1162/074793601750357196

Dorrestijn, Steven. 2012. "The Design of Our Own Lives: Technical Mediation and Subjectivation after Foucault." Doctoral dissertation, University of Twente.

Dourish, Paul, and Melissa Mazmanian. 2013. "Media as Material: Information Representations as Material Foundations for Organizational Practice." In *How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies*, ed. Paul R Carlile, Davide Nicolini, Ann Langley, and Haridimos Tsoukas. Oxford: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199671533.001.0001

Ellul, Jacques. (1954) 1964. *The Technological Society*, trans. John Wilkinson. New York: Vintage Books.

Fallman, Daniel. 2011. "The New Good: Exploring the Potential of Philosophy of Technology to Contribute to Human-Computer Interaction." In *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems*. New York: Association for Computing Machinery, 1051–60. http://dx.doi.org/10.1145/1978942.1979099

Feenberg, Andrew. 1999. "Democratizing Technology." In *Questioning Technology*, 131–47. New York: Routledge.

Fernaeus, Ylva, and Petra Sundström. 2012. "The Material Move: How Materials Matter in Interaction Design Research." In *Proceedings of the Designing Interactive Systems Conference*. New York: Association for Computing Machinery, 486–95. http://dx.doi.org/10.1145/2317956.2318029

Golbeck, Jennifer. 2013. "On second thought . . . : Facebook Wants to Know Why You Didn't Publish that Status Update You Started Writing." *Slate*, December 13.

Greenwald, Glenn, and Ewen MacAskill. 2013. "NSA Prism Program Taps In to User Data of Apple, Google and Others." *The Guardian*, June 6.

Grudin, Jonathan. 1990. "The Computer Reaches Out: The Historical Continuity of Interface Design." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York: Association for Computing Machinery, 261–68. http://dx.doi.org/10.1145/97243.97284

Harman, Graham. 2009. *Prince of Networks: Bruno Latour and Metaphysics*. Re-press. http://re-press.org/books/prince-of-networks-bruno-latour-and-metaphysics/.

Hasse, Cathrine. 2008. "Postphenomenology: Learning Cultural Perception in Science." *Human Studies* 31(1): 43–61. http://dx.doi.org/10.1007/s10746-007-9075-4

Heidegger, Martin. 1977. *The Question Concerning Technology and Other Essays*, trans. William Lovitt. New York: Harper Perennial.

Heidegger, Martin. (1953) 2010. *Being and Time*, trans. Joan Stambaugh. Albany: State University of New York Press.

Ihde, Don. 1990. *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press.

Janlert, Lars-Erik, and Erik Stolterman. 2010. "Complex Interaction." *ACM Transactions on Computer-Human Interaction (TOCHI)* 17(2): 1–32. http://dx.doi.org/10.1145/1746259.1746262

Jung, Heekyoung, and Erik Stolterman. 2012. "Digital Form and Materiality: Propositions for a New Approach to Interaction Design Research." In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design*, 645–54. New York: Association for Computing Machinery. http://dx.doi.org/10.1145/2399016.2399115

Kallinikos, Jannis. 2013. "Form, Function, and Matter: Crossing the Border of Materiality." In *Materiality and Organizing: Social Interaction in a Technological World*, ed. Paul M. Leonardi, Bonnie A. Nardi, and Jannis Kallinikos, 67–87. Oxford: Oxford University Press.

Kiran, Asle H. 2012. "Responsible Design: A Conceptual Look at Interdependent Design-Use Dynamics." *Philosophy & Technology* 25(2): 179–98. http://dx.doi.org/10.1007/s13347-011-0052-5

Kroes, Peter. 2001. "Technical Functions as Dispositions: A Critical Assessment." *Techné: Research in Philosophy and Technology* 5(3). http://scholar.lib.vt.edu/ejournals/SPT/v5n3/kroes.html

Latour, Bruno. 1999. *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, MA: Harvard University Press.

Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. New York: Oxford University Press.

MacKenzie, Donald. 1996. *Knowing Machines*. Cambridge, MA: MIT Press
Marcuse, Herbert. (1964) 1991. *One-Dimensional Man: Studies in the Ideology of Advanced Industrial Society*. Boston: Beacon Press.
Mumford, Lewis. (1934) 2010. *Technics and Civilization*. Chicago: University of Chicago Press.
Nelson, Harold G., and Erik Stolterman. 2012. *The Design Way: Intentional Change in An Unpredictable World*, 2nd ed. Cambridge, MA: MIT Press.
Norman, Donald A. 1988. *The Design of Everyday Things*. New York: Currency Doubleday.
Norman, Donald A. 1999. *The Invisible Computer: Why Good Products Can Fail, the Personal Computer Is So Complex, and Information Appliances Are the Solution*. Cambridge, MA: MIT Press.
Redström, Johan. 2005. "On Technology as Material in Design." In *Design Philosophy Papers: Collection Two*, ed. Anne-Marie Willis, 31–42. Ravensbourne, Qld.: Team D/E/S Publications.
Rittel, Horst W. J., and Melvin M. Webber. 1973. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4(2): 155–69. http://dx.doi.org/10.1007/BF01405730
Rosenberger, Robert. 2013. "Mediating Mars: Perceptual Experience and Scientific Imaging Technologies." *Foundations of Science* 18(1): 75–91. http://dx.doi.org/10.1007/s10699-012-9286-7
Schön, Donald A. 1983. *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.
Simon, Herbert A. 1969. *The Sciences of the Artificial*. Cambridge, MA: MIT Press.
Suchman, Lucy A. 2007. *Human-Machine Reconfigurations: Plans and Situated Actions*, 2nd ed. Cambridge: Cambridge University Press.
Sundström, Petra, and Kristina Höök. 2010. "Hand in Hand with the Material: Designing for Suppleness." In *Proceedings of the 28th International Conference on Human Factors in Computing Systems*. New York: Association for Computing Machinery, 463–72. http://dx.doi.org/10.1145/1753326.1753396
Sundström, Petra, Alex Taylor, Katja Grufberg, Niklas Wirström, Jordi Solsona Belenguer, and Marcus Lundén. 2011. "Inspirational Bits: Towards a Shared Understanding of the Digital Material." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '11. ACM. New York: Association for Computing Machinery. http://doi.acm.org/10.1145/1978942.1979170.
Verbeek, Peter-Paul. 2005. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. University Park: Pennsylvania State University Press.
Verbeek, Peter-Paul. 2008. "Obstetric Ultrasound and the Technological Mediation of Morality: A Postphenomenological Analysis." *Human Studies* 31(1): 11–26. http://dx.doi.org/10.1007/s10746-007-9079-0

Verbeek, Peter-Paul. 2011. *Moralizing Technology: Understanding and Designing the Morality of Things*. Chicago: University of Chicago Press. http://dx.doi.org/10.7208/chicago/9780226852904.001.0001

Weiser, Mark. 1991. "The Computer for the 21st Century." *Scientific American* 265: 66–75. http://dx.doi.org/10.1038/scientificamerican0991-94

Wiberg, Mikael, and Erica Robles. 2010. "Computational Compositions: Aesthetics, Materials, and Interaction Design." *International Journal of Design* 4(2): 65–76.

Wiltse, Heather. 2013. "The Mediating Role of Responsive Digital Materials: A Conceptual Investigation and Analytic Framework." Doctoral dissertation, Indiana University.

Wiltse, Heather, and Erik Stolterman. 2010. "Architectures of Interaction: An Architectural Perspective on Digital Experience." In *NordiCHI '10: Proceedings of the 6th Nordic Conference on Human-Computer Interaction*. New York: Association for Computing Machinery, 821–24. http://dx.doi.org/10.1145/1868914.1869038

Winner, Langdon. 1986. *The Whale and the Reactor: A Search for Limits in An Age of High Technology*. Chicago: University of Chicago Press.

Wittkower, Dylan E., Evan Selinger, and Lucinda Rush. 2013. "Public Philosophy of Technology." *Techné: Research in Philosophy and Technology* 17(2): 179–200. http://dx.doi.org/10.5840/techne201317212