Laura Forlano

Towards an Integrated Theory of the Cyber-Urban. Digital Materiality and Networked Media at Multiple Scales

2015

https://doi.org/10.25969/mediarep/731

Veröffentlichungsversion / published version
Zeitschriftenartikel / journal article

Towards an Integrated Theory of the Cyber-Urban

Digital Materiality and Networked Media at Multiple Scales

Laura Forlano

Abstract

Over the past decade, scholars have worked to develop a new lexicon of the cyber-urban in order to express, in a more nuanced and careful way, the hybrid nature of everyday life in cities of the 21st century. Yet, for the most part, our current verbal and visual metaphors and imagined futures along with our theoretical and analytical frames, to a large degree, continue to emphasize the separation of the physical and the digital into discrete and hierarchical layers and 'stacks.' Given our limited metaphors, it should come as no surprise that we are unable to traverse socio-economic barriers and build more equitable and pluralistic cities. This paper will discuss the need to move beyond hybrid language and towards a truly integrated theory of digital materiality and the cyber-urban using examples from debates about big data, Smart Cities, the 'internet of things' and the quantified self.

Introduction

We are living in a time of hybrids. Of bits and atoms. Of code and place. Yet, our tongues are tied when we attempt to describe the everyday realities of our own existence. The verbal and visual metaphors that we encounter on a daily basis whether in science fiction movies, video press releases for augmented reality platforms, architecture fly throughs, the mainstream media and even in scholarly writing herald back to the 1960s defence department funded research at MIT (if not before). We are told that digital information layers are invisibly and ubiquitously covering our cities. This paper is about these 'digital layers,' which are often presented as discrete and hierarchical much like the sociotechnical systems on which they are based.

While the lived experience of cities denies the rhetoric of layers, it is not enough to talk about digital material hybrids. For the past decade, scholars have worked to develop a new lexicon of the cyber-urban, which can build on and advance the notion of hybrids with more nuanced and careful metaphors and imagined futures. It is only when we are able to move beyond our current discourses of the cyber-urban, which despite the best of intentions continue to

DOI 10.14361/dcs-2015-0106

emphasize separation and distinction, that we will be able to traverse socio-economic barriers and build more equitable and pluralistic cities. This paper takes a multi-scalar approach to analysing the cyber-urban using a wide variety of empirical examples from science fiction and new media art to ethnographic accounts of networked bodies in everyday urban life.

Background

> "It's All in How You Look at Things."
> Alec Bings in Norton Juster's *The Phantom Tollbooth*

This paper presents an integrated theory of the cyber-urban, which is premised on the need to move beyond our current language of hybrids. Specifically, this paper advocates for a multi-scalar approach rather than one premised on levels, layers and stacks as is common in mainstream and academic discourse on sociotechnical systems. The cyber-urban is one example of an analytical frame that takes into account sociotechnical systems as they are embedded in the networked geographies of cities. In order to apply a multi-scalar approach to the understanding of the cyber-urban, it is necessary to zoom in and out of a range of sociotechnical configurations.

In this paper, I will offer examples at a variety of scales including: Networked Cities, Networked Objects and Networked Bodies. Networked Cities (the cyber-urban) include debates around big data, smart cities and urban informatics such as telecommunications and transportation infrastructure and the built environment. Networked Objects includes the 'internet of things' as manifested in connected street furniture, adaptive traffic signals and parking meters with dynamic pricing. Finally, Networked Bodies includes augmented reality as well as medical devices and the quantified self. By taking a multi-scalar approach, I will be able to develop a more nuanced understanding of digital material hybrids.

In Chapter 9 of Norton Juster's *The Phantom Tollbooth* (1961), the author presents a curious character, Alec Bings, a man that appears to be floating in air. When presented with the beauty of a lush green landscape, he exclaims "It's all in the way you look at things" (ibid.: 103), saying that the landscape might not appear to be beautiful at all to someone that preferred a view of the desert. The book also emphasizes the themes of scale and perspective in a later chapter. In it, Milo, the young boy who is the story's main character, and his dog Tock get lost. They come upon a small house between two trees with a brass name plate on the door that says, 'The Giant.' However, when the door opens, they see a 'perfectly ordinary-sized man' who sends then around the back of the house to see, 'The Midget.' Similarly, the midget, who is identical to the giant, sends them to 'The Fat Man' and he sends them to 'The Thin Man.' While in the novel, all four men at the house are the same, these two vignettes – about Alec Bings and 'The Giant' – illustrate the importance of multiple scales and perspectives.

Few disciplines, fields or sub-disciplines are equipped to analyse sociotechnical phenomenon from multiple scales. For example, to put it crudely, in the social sciences, psychologists study cognitive processes, anthropologists study individuals and cultures, sociologists study organizations and communities, and urban planners study cities. As a social scientist based at a graduate design school, I recognize the disciplinary gaps (both theoretical and methodological) that offer possibilities for design. In particular, I believe in the value of bringing together the critical and rigorous theoretical stance of the social scientist while, at the same time, allowing for the generative potential of design. This is particularly important with respect to considerations of sociotechnical systems and, in particular, the cyber-urban.

Design is a field that necessitates the movement across these categories, which are often separated by disciplinary boundaries. Interdisciplinary, cross-disciplinary and transdisciplinary approaches also require the collapse of traditional divides. In a lecture in September 2013, 'From Sustainable Design to Transition Design,' at the Institute of Design at Illinois Institute of Technology design philosopher Cameron Tonkinwise argued, 'In order to work on sociotechnical change, you must work at the macro, meso and micro levels simultaneously.' Rather than proceeding from project to project in a linear fashion, it is necessary to engage in multiple projects at the same time. While Tonkinwise's remarks were directed primarily towards 'transition design' and issues of environmental sustainability, they are equally if not more relevant towards understanding other areas of sociotechnical change such as the cyber-urban. This emphasis on engagement at multiple scales – the global, the national, the community – as a strategic and analytical frame is also emphasized in discussions of feminist activism (Gibson-Graham 2006).

By moving from analytic categories predicated on discrete layers to engaging with the cyber-urban at multiple scales, one can participate in a kind of reflexive zooming in and zooming out that allows for the building of theoretical and methodological connections across these scales. Within the context of scholarship and practice, this reflexive zooming in and out, with certain things coming into focus and other things being blurred, is experienced as almost a form of intellectual nausea, a roller coaster for which few are trained to think. By zooming in and re-focusing, even briefly, on examples from three different scales Networked Cities, Networked Objects and Networked Bodies, it is possible to develop new capacities that cross these ontological boundaries such as the city-object, the object-body, the city-body.

In addition to working across multiple vantage points, design can traverse the past, present and future in a way that many other disciplines and fields cannot. Design can also rely on the affective power of facts as well as that of fiction. For example, by using a combination of scenarios and storytelling through design fiction as well as drawing on empirical evidence collected through field research and secondary sources, designers can open up questions for discussion of alternative future possibilities. As such, the work of artists and designers, particularly those engaged with new media and digital technologies, is useful for exploring questions related to the cyber-urban.

From The Matrix to The Fifth Estate and Elysium

One important site of cyber-urban narratives can be found within popular culture and, specifically, in science fiction films as well as in dramatic semi-factual re-enactments of true stories. To quote Donna Haraway reflecting on the work of British social anthropologist Marilyn Strathern, author of *The Gender of the Gift*, "It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what ties tie ties. It matters what stories make worlds, what worlds make stories" (2011: 3). Films are only one component of what Haraway calls 'worlding,' the ways in which we construct knowledge and worlds through engagement with 'thick material and narrative tissues' drawn from the 'factual, fictional, and fabulated,' (Haraway 2011: 2).

Depictions of the cyber-urban in science fiction films and dramas have changed little since the Wachowski Brothers' 1999 cyber-punk film The Matrix. In order to convey the relationship between the 'real' world and the simulated, digital one, the directors used the metaphor of streaming green vertical characters. While the original film was intended as a dystopian future, it underscored the notion that the digital world was a discrete layer of information that was on top of or in place of the real world. Similarly, in the 2013 film about WikiLeaks *The Fifth Estate*, the main characters Julian Assange and his collaborators are frequently portrayed in an orb of glowing green code in a dark, placeless, seemingly never-ending room full of desks and computers.

While we pay frequent lip-service to the concept that the digital and the material world are becoming more integrated, acknowledging our hybrid existence, the integration of the digital and the physical are not occurring in a seamless, ubiquitous or placeless manner. Yet, we continue to let rational, Western and objective logics shape the metaphors that we use to describe these new hybrids. Layered maps with discrete social and technical slices, architecture fly throughs and video game interfaces and augmented reality views of the world continue to complicate our understanding of the cyber-urban. Instead, metaphors that hint at digital ghosts and shadows (things that are there and simultaneously or sometimes absent) or mutants and zombies (things that are active and orderly but also dormant and misbehaving) might be more apropos.

At the same time that the digital and the physical are being joined in many interesting and important ways, we find that our socio-economic conditions are increasingly disparate, separated and unequal. For example, in the recent science fiction film Elysium, by South-African-Canadian director Neill Blomkamp and Matt Damon, the world has descended in to a dystopia in which the poor, non-white population must live in squalor on Earth working for a factory that makes robots while the wealthy have moved to a man-made country club in the sky. While intended as dystopian science fiction, the film's plot embeds within it the ongoing Silicon Valley dream of Libertarian escape from the controls of government. Such dreams are prevalent in narratives around alternative electronic currencies such as Bitcoin, the rhetoric around digital fabrication technologies such as 3-D printing and routing systems such as the Tor Project.

These stories are primarily intended to entertain and, perhaps, to spark discussions about our current conditions. My intent is not to criticize the filmmakers for failing to adequately represent the hybrid conditions that shape our lived reality but, rather, to illustrate just how complex the depiction of such worlds is both linguistically as well as visually. Yet, these science fiction and science fact worlds continue to provide visual metaphors that both expand and constrain our ability to think about digital-material relations.

Design, informed by social science and other disciplines, can take these scenarios and stories as a starting point to create prototypes, probes and platforms around and through which it is possible to discuss alternative future realities and possibilities. Unless we can move beyond superficial discussions of hybrids and towards more nuanced understandings, we will continue to perpetuate intellectual distance and misunderstanding. In this definition of hybrids, I include a wide range of relationships that are frequently framed as dichotomies: digital/material (and the cyber-urban), public/private, local/global, individual/community, human/non-human, mind/body, fact/fiction, black/white, rich/poor etc. These dualistic understandings of the world continue to persist despite efforts to view them as hybrid, which, in turn, makes it even more difficult to move beyond mere hybrids. For example, if we are living in a time of digital material hybrids, in what way are they hybrid? What is the digital and what is the material? What are the temporal and spatial relationships between the digital and the material? To return to the earlier example from The Phantom Tollbooth, our understanding of hybrids is a matter of scale, perspective and, ultimately, how we look at things.

Theoretical Framework

Let's start with a lesson from quantum physics. Last winter, while on vacation, I came across an article on an article on supersymmetry, the idea that each of the 17 known particles has a nearly identical (but yet undiscovered) cousin. For example, particles have sparticles, neutralinos have gravitinos, photons have photinos, electrons have selectrons, quarks have quarks and gluons have gluinos (Craig 2013). What I find so exciting about this idea (for it is not known if it is real or not) is the creation of properties, relationships and behaviours for things that are difficult (if not impossible) to observe. This is not unlike my search for concepts to describe digital materiality – the blurring of digital and material categories – which is so important for understanding the ways in which cities, objects and, indeed, our own bodies are changing as we engage with (or attempt to avoid) digital and networked media.

The desire to transcend discrete categories such as digital and material has been evident in scholarship from the early pragmatists that defied universal categories to the post-structuralists, post-colonialists and feminists. For example, Haraway's "A Cyborg Manifesto" advocates for the rejection of rational, Western dualisms and towards an understanding that these boundaries are constantly being traversed. For Haraway, "A cyborg is a cybernetic organism, a

hybrid of machine and organism, a creature of social reality as well as a creature of fiction" (1991: 23). Yet, despite the fact that over 20 years has passed since Haraway's manifesto, her words are still as relevant as ever because we have not succeeded in adequately describing or fully understanding the hybrids that inhabit her text.

Benjamin Bratton's work on planetary-scale computation reconsiders geography in an age of cloud computing, ubiquitous computing and augmented reality through the introduction of an analytical frame called the 'the stack,' which is defined as

"[...] that vast software/hardware formation, a proto-megastructure of both bits and atoms, literally circumscribing the planet, which, as said, not only perforates and distorts Westphalian models of State territory, it also produces new spaces in its own image: clouds, networks, zones, social graphs, ecologies, megacities, formal and informal violences, weird theologies, each superimposed one on the other." (Bratton 2011)

While, on the one hand, the stack is an attempt to transcend the dichotomy between bits and atoms, at the same time, in borrowing from the language of computer science and Internet architecture, it continues to reify the notion of layers. He writes:

"The Stack, as we encounter it and as I prototype it, is composed equally of social, human and 'analog' layers (chthonic energy sources, gestures, affects, user-actants, interfaces, cities and streets, rooms and buildings, organic and inorganic envelopes) and informational, non-human computational and 'digital' layers (multiplexed fiber optic cables, datacenters, databases, data standards and protocols, urban-scale networks, embedded systems, universal addressing tables)." (Bratton 2011)

In light of this description, theories from science and technology studies, organizational studies and design are particularly useful in describing more complex understandings of hybrids related to digital materiality, which are most relevant to debates about cyber-urbanism. The social construction of technology (Pinch/Bijker: 1984) and Actor-Network Theory (ANT) are important frameworks from science and technology studies, which underpin any study of the cyber-urban. Specifically, Actor-Network Theory dismisses structural accounts of levels and layers, which consistently are invoked to discuss sociotechnical arrangements of augmented reality, drones and location-based applications among other realities of hybrid living. According to Latour, ANT is:

"[...] a change of topology. Instead of thinking in terms of surfaces – two dimension – or spheres – three dimension – one is asked to think in terms of nodes that have as many dimensions as they have connections. As a first approximation, the AT claims that modern societies cannot be described without recognizing them as having a fibrous, thread-like, wiry, stringy, ropy, capillary character that is never captured by the notions of levels, layers, territories, spheres, categories, structure, systems. It aims at explaining

the effects accounted for by those traditional words without having to buy the ontology, topology and politics that goes with them." (1996: 125)

Both Actor-Network Theory and object-oriented ontology (Bogost 2012) with their calls to give credit to the agency of things in sociotechnical systems are important. The cyber-urban invokes all manner of sociotechnical configurations that triangulate people, animals, buildings, technologies, environmental resources, transportation systems, legal codes and places to name just a few. More recently, many scholars across organization studies, feminist studies and media studies have observed that we are currently experiencing a (re)turn to materialism (Barad 2003; Bennett 2009; Carlile/Langley 2013; Gillespie/Boczkowski/Foot 2014). Yet, this new materialism is emerging in the context of networked and digital media in which some infrastructures, objects and bodies are linked, networked and connected – sometimes intermittently, partially or disparately – while others are not. The uneven distribution of and varying forms of connectivity raise important sociotechnical (also to be understood as cultural, political and economic) questions: about the nature of temporality and the construction of notions about 'the future,' place and situatedness, identity and culture as well as broader question around civic engagement, equality and democracy.

This new materialism and, more specifically, notions about the nature of digital materiality are a reaction to the pervasive depictions of the immateriality of digital information, which frequently appear in mainstream media and scholarly accounts of technology (Blanchette 2011; Rosner et al. 2012). Modularity, layers and stacks are the materiality organizing principles of digital information and they have also permeated other realms of sociotechnical organization such as architecture and product design. Blanchette argues that, 'Yet, we today have neither technical language nor intuition for something akin to the tensility, durability, or density of computing resources. Without a basic understanding of the material constraints under which computing systems operate, essential dynamics that animate the built environment of the virtual will remain invisible and unaccounted for,' (2011). Similarly, Anna Munster argues that there is a 'differential logic,' which:

"[...] places body and machine, sensation and concept, nature and artifice in ongoing relations of discordance and concordance with each other...In this 'force-field' the binary pairs that have populated our understanding of digital culture and new media technologies – physicality and virtuality, analog and discrete states, real and hyperreal – can be seen to impinge upon each other rather than be mutually exclusive. The effect of these areas' convergences and divergence is to produce ever-new and consistently mutating outcomes." (Munster 2006: 5)

For Munster, digital material relations consist of embodied assemblages, clusters and 'folds' that redefine Cartesian geographies, which have long divided mind from body.

Dourish and Mazmanian (2011) present five types of digital materiality including: 1. material culture of digital goods; 2. transformative materiality of digital networks; 3. material conditions of information technology production; 4. consequential materiality of information metaphors; and, 5. materiality of information representation. For the purposes of the cyber-urban, their second category, the transformative materiality of digital networks is most relevant. Specifically, Dourish and Mazmanian write, "The availability of infrastructures organizes and contextualizes human action and the various meanings that space can have, both in the small (e.g. cell phone dead zones, WiFi-enabled cafes, broadband-connected homes) and in the large (e.g. cities differentiated by their data infrastructure, concentrations of manufacturing industry, regions marked by different approaches to regulation of digital services or the allocation of wireless spectrum.)" (2011: 97) This "cultural geography of information technologies, from the spatial politics of digital urbanism to the reshaping of public space through WiFi and WiMax networks" (Dourish/Mazmanian: 2011) and the focus on infrastructure and the built environment as well as novel forms of virtual organization such as the ways in which Wi-Fi networks afford new configuration and arrangements of humans and devices in physical spaces, which I have discussed in earlier work (Forlano 2009). They describe a range of material properties such as mutability, persistence, robustness, spatiality, size, durability, flexibility, and mobility.

Leonardi (2010) discusses the materiality of digital artefacts from a physical as well as a conceptual viewpoint in the field of organization studies. Specifically, he is concerned with the materiality of digital artefacts as 1) practical instantiation of theoretical ideas; and, 2) their significance in the explanation of a given context. Orlikowski (2007) emphasizes the inseparable, constitutive entanglement of the social and the technical, saying that sociotechnical arrangements are multiple, emergent and dynamic. She draws on the theory of affordances (Gibson 1977) as well as Actor-Network Theory and theories of performativity (Barad 2003) to illustrate the ways in which the relationships between the social and the technical are enacted together in a network.

The implications of these theoretical advances have also been discussed in the field of design and computation in which designers are experimenting with information, 'immaterials' and 'information shadows' as a new material for design (Arnall 2012; Arnall/Knutsen/Martinussen 2013; Kuniavsky 2010), science fiction (Bell/Dourish 2007), design fiction (Bleecker 2009), critical design (Dunne 2001), critical making (Ratto 2011), speculative fabulation (Haraway 2011) and speculative design (DiSalvo 2012b) in order to better understand the nature of digital materiality. Robles and Wiberg refer to the creation of 'digital-physical compositions' or 'computational compositions' in the 'material turn' within interaction design (2010; 2011; 2010).

Similarly, these digital-material relations have been referred to as hybrid ecologies (Crabtree/Rodden 2008) and material traces (Rosner et al. 2013). In human-computer interaction (HCI), computational materiality itself can be viewed as a medium (Gross/Bardzell/Bardzell 2014). For HCI, the move from material to materiality can also been seen as a move from practice to

theory (Rosner et al. 2012). In urban design and urban informatics, digital materiality is manifested in interactive infrastructures and mediated spaces that are changing the ways in which the 'city is enacted' (Fors/Wiberg 2010). Still, other writing questions the need to continue to name the multiple ways in which the digital has intertwined itself in the material world (Bean/Rosner 2013).

In the more specific fields of urban communication, urban informatics, architecture, urban planning and geography, the material, place-based nature of the digital has been long recognized. Such studies have examined, for example, emergent forms of organizing (Humphreys 2008), new modes of citizen engagement (Foth 2008; Foth, et al. 2011) and novel ways of experiencing and navigating cities (Ito 2003). Hybrid terminologies – net locality (Gordon/Silva 2011), codescapes (Forlano 2009, 2013), code/space (Kitchin/Dodge 2011), situated technologies (Shepard 2011), media spaces (Couldry/McCarthy 2004), Hertzian space (Dunne 2001), neogeography (Turner 2006), neomaterialism (Simon 2013), radical network empiricism (Mackenzie 2010) – have been introduced but they have not been widely adopted. In his 2005 book, *Shaping Things*, Bruce Sterling laid out a manifesto of sorts for designers in which he proposed the neologism of 'spimes' in order to capture:

> "[...] manufactured objects whose informational support is so overwhelmingly extensive and rich that they are regarded as material instantiations of an immaterial system. Spimes begin and end as data. They are designed on screens, fabricated by digital means, and precisely tracked through space and time throughout their earthly sojourn." (Sperling 2005: 79)

One of the key features of spimes is that they are embedded with sensors that measure and record changes and, thereby, have the potential to transform our understandings of temporal perception – 'an historical entity with an accessible, precise trajectory through space and time,'. This identity as a track-able digital-material object with RFIDs (radio-frequency identification tags or 'arphids' according to industry slang) allow for new relationships to time and space. This has profound implications for the economy according to Sterling because 'value transmutes into a public interaction with past and future. It's not about the material object, but where it came from, where it is, how long it stays there, when it goes away, and what comes next,'. Similar to the historical role of the telegraph in the creation of the futures market, Sterling argues that the significance of spimes is that every market will become a futures market. To this rich discussion of future digitally material objects, Sterling adds the notion of 'biots,' defined as 'an entity which is both object and person,' enabled by cybernetics, biotechnology and cognition.

Discussion

Mainstream discussions about digital and networked media at the urban, object and body scale often reinforce the ways in which digital technologies – big data, smart cities, the 'internet of things' and the quantified self – can increase efficiency, innovation, security and awareness of places, things and ourselves. By examining recent examples of the use of digital technologies, art and design projects as well as ethnographic accounts, it is possible to better understand the ways in which scholarly discussions of digital materiality are paving the way towards an integrated theory.

Networked Cities: Big Data at the Border

As a member of the United States Customs and Border Protection Global Entry program, I am able to use a digital kiosk rather than a paper customs form in order to enter the country. Recently, on a trip back to O'Hare, I received a paper customs form on the plane and declined to fill it out expecting that I would use the Global Entry terminal. However, upon arrival, I found that all of the many terminals were not functioning properly. Believing that I would eventually find one that would work, I tried the digital entry process – scanning my passport, typing in my flight number – at about three different terminals. This example is relevant in that we are increasing relying on digital and networked media to regulate our entry/exit of national boundaries, interstate highways, transportation systems and buildings. What happens when these systems break down and who will fix them? Who is best able to take advantage of these systems due to their demographic characteristics such as socio-economic standing and who will be excluded? Should we opt-out of such programs merely on the basis that they further discriminate between richer and poorer citizens? What are the implications on the embodied, lived experience of travelling through physical space?

Theories of digital materiality and the cyber-urban can capture these nuances more deeply by understanding city-objects and city-bodies as assemblages of people, machines and spaces that define emergent geographies in relational, shifting and dynamic ways. We might understand the terrains in which these various alignments and contradictions take place as neogeographies or codescapes; sometimes offering smooth and seamless passage through spaces, which go almost unnoticed and, at other times, creating productive frictions that alert our attention to inequalities that have been encoded into digital systems on the basis of nationality, socio-economic status, gender, race, sexuality, ability or any number of other criteria. Yet, as scholars of the digital material, we are only grasping towards potential ways of describing these emergent conditions and, it is possible that the relevant language will only come with new sociotechnical configurations that act as demonstrations, prototypes and experiments for alternative analytic frames.

Networked Objects: The Garbage Can Took Your Job

City systems and infrastructures are increasingly embedded with networked devices and artefacts, sometimes referred to as the 'internet of things.' This includes networked traffic signals, garbage cans, parking meters, vending machines, energy monitors and environmental sensors. In order to better understand the possibilities and constraints of networked objects, it is helpful to survey a range of artistic and commercial projects.

The 2009 Towards the Sentient City exhibit at the Architecture League of New York included a range of artistic projects that help to raise awareness and question the use of urban technologies. One of the projects, *Trash Track* by the *SENSEable City Laboratory* (Massachusetts Institute of Technology) considers the 'removal-chain' in cities and the ways in which visualizing the process of trash removal can lead to the building or more sustainable infrastructure. The project uses small wireless location-aware tags in order to follow garbage through a city's waste management system. For example, the project follows a typical Brown Coffee Cup over 7 days, 8 hours and 42 minutes on its journey in Seattle, WA from trashcan to dumpsite. The goal of the project is to develop "a bottom-up approach to managing resources and promoting behavioral change through pervasive technologies."[1]

Another project, *Too Smart City*, a project by JooYoun Paek and David Jimison and engineered by Daniel Bauen, Aaron Gilbert and Bill Washabaugh, uses ubiquitous computing to present a critique of urban technology through the creation of a *Smart Bench*, *Smart Sign* and a *Smart Trashcan*. For example, the Smart Bench discourages vagrancy and loitering and the Smart Trashcan spits out garbage that has been incorrectly discarded. The project transforms street furniture into 'representatives of sanitation and control' and 'presents technological solutions to current problems in these systems, but as failures, rather than as progress: a future where everyday objects are rendered non-functional by their overly enthusiastic usage of computational intelligence.'[2]

In addition to the artistic examples, there is a growing list of commercial examples of the use of networked objects in city planning and management. For example, *Midtown in Motion*, a 'congestion management' project in New York City, uses sensors, video cameras and E-ZPass readers to measure traffic speeds and has resulted in a 10% improvement in travel speeds. Furthermore, the traffic data and video streams are available in real-time on the City's Department of Transportation website.[3] SF*park* is a system established by the San Francisco Metropolitan Transit Authority in order to reduce traffic and improve parking through the use wireless parking sensors and smart meters that use real-time data about parking availability and demand-responsive pricing. The project is currently being piloted in selected neighbourhoods in San Francisco.[4] *Lapka*

1 cf. http://www.sentientcity.net/exhibit/?p=31.

2 cf. http://www.sentientcity.net/exhibit/?p=59.

3 cf. http://www.nyc.gov/html/dot/html/pr2012/pr12_25.shtml.

4 cf. http://sfpark.org/about-the-project/.

is a personal environment monitor that plugs into a smart phone in order to measure humidity, radiation, nitrates, and electromagnetic fields. The collected data is visualized and displayed through the *Lapka* application.[5]

Let's take an example from mundane urban street furniture – the *Big Belly* solar compactor, which can be found in numerous American cities as well as around the world. This seemingly benign technology dubbed 'smart trash can' is embedded with a sensor that allows it to communicate when it needs to be emptied. With its large, opaque rectangular design, there is no mistaking its material affordances, which up considerable space on street corners. Yet, its digital components are hidden invisibly within as are questions of values, equality and social justice. According to the company's website, each trash can costs up to $2,000 to empty.[6] The Big Belly promises to 'free up labour' because it only needs to be emptied when full, thereby improving the efficiency of driving routes. Thus, while the environmental benefits of the Big Belly are advantageous from a recycling and sustainability perspective (including saving on fuel costs, its labour implications are buried under a pile of trash (so to speak). Another observation about the Big Belly trash can is that it requires one to pull a handle in order to open it. While the company claims that its design reduces litter, I can attest to the fact that, rather than gripping the handle to open it, I've sometimes walked around for hours with a coffee cup until I come across one with a traditional wire frame that does not require bodily contact. In conversations with an architect at the Harvard Graduate School of Design, I learned of a Big Belly trash can in a residential neighbourhood that was constantly buzzing with flies due to its opaque rather than open design and, thus, further deterring people from using it.

So, who are the 'missing masses' (Latour 1992) that will be displaced in this piece of mundane urban infrastructure? How is the digital reconfiguring systems of garbage collection and recycling? Asking these questions about the many products and services that are being introduced under the banner of the 'internet of things' has great value for a deeper understanding of digital materiality. Indeed, the smart trash bin is not merely a digitally augmented version of an old thing. Nor is it merely an attractive hybrid of digital and material. Rather, it is an entirely new actor in the reconfiguration of socio-economic relations around the labour of trash collection and transforming the ways in which people engage with their trash as well as altering the multi-species relations (Haraway 2003; 2008) with flies.

Borrowing Bruce Sterling's term, the Big Belly and other city-objects such as adaptive traffic signals, smart street furniture and dynamic pricing parking meters might be understood as spimes – networked objects with identities, relationships, histories and trajectories that have the potential to transform economies. According to Chris Speed, the word spime is a mash-up of space and time referring to 'objects that are in contact with the Internet all the time, constantly telling the world where they are and what time they are there, as

5 cf. https://mylapka.com.

6 cf. http://www.bigbelly.com/places/cities/.

though they are new coordinates that will define how we map reality.' Speed differentiates spimes between 'Things That Are Actually in the World' such as the tracking of physical objects and 'Things That Are Not Actually in the World,' such as things that have locative, social and virtual data despite the fact that they no longer have a material form. Yet, despite the potential usefulness of these terms they have failed to become more widespread outside of a small group of designers and technology-enthusiasts. For example, while 2014 has been widely heralded by the mainstream media as the year of the 'internet of things,' an recent in-depth article in the *Harvard Business Review* includes no references to these specific terms.

Networked Bodies: My FitBit is Dead and My Wireless Scale Has Forgotten Who I Am

With respect to technologies of the body, a wide range of 'quantified self' applications have emerged in recent years in particular in the health and exercise arena. For example, the *Fitbit* and wireless scale, Nike+ and Nike Fuel Band, Jawbone Up wristbands and trackers as well as their online applications allow for the collection of real-time data of distances (steps, miles), calories, exercise and food intake.[7] Health and medical technologies are also relevant when it comes to technologies of the body. Fashion, wearables and textiles are another area in which technologies from sensors to QR codes and smart fabrics are increasingly embedded in or on the body. This includes design fiction concepts by Philips Design for biosensor-enabled jewellery and digital tattoos, augmented reality platforms such as Google Glass and t-shirt company W-41, which allows for urls to be encoded into graphical logos on textiles.[8] Finally, cyborg Steve Mann, who pioneered one of the first wearable computers, and artist StelARC, who has grafted an ear onto his arm, have been among the earliest people to experiment with embedding digital and biological technologies in their body.[9]

Discussions of the quantified self focus largely on behaviour change through the self-tracking and sharing of data such as calories burned, miles walked or stairs climbed. What kind of cyborg (Haraway 1991) hybrids are these digital material entities that can be found jogging throughout our cities with colourful wristbands? Surely, they are more than their disembodied datafeeds and data shadows (Shelton/Poorthuis/Graham/Zook 2014). This focus on the transmission of information rather than its ritual embodied experience (Carey 1988) – or *data rituals* as I call them – continues to future the disconnection between the digital and the material. I have been using a *FitBit* on and off since

7 See http://www.fitbit.com/flex, http://store.nike.com/us/en_us/pd/fuelband/pid-669575/pgid-670534, http://store.jawbone.com/store/aliphcom/DisplayHomePage.

8 See http://www.design.philips.com/philips/sites/philipsdesign/about/design/designportfolio/design_futures/electronic_sensing_jewelry.page, http://www.google.om/glass/start/, http://w-41.comm.

9 See http://stelarc.org/?catID=202477.

March 2011. Like many users of so-called quantified self technologies, the data begins to lose meaning after one learns their everyday patterns. 5000 steps to work and back. 300 calories burned on an hour-long walk or a Zumba class. While my enthusiasm at the start was high, the mere transmission of data was uninspiring. The more ritual, embodied experiences include the ways in which wearing such a device reinforces one's identity or allows them to participate in a community. Today, my blue *FitBit* Flex lies 'dead' next to random keys, loose change, business cards, safety pins and buttons in a tray next to the TV. It stopped working and I have not been compelled to replace it. Over the summer, my wireless scale – which had greeted me by name for almost two years – has forgotten who I am, only referring to me as 'guest.' These examples give additional meaning to the notion of digital materiality as it plays out in everyday life.

The language of the cyborgs as a hybrid of human and machine has perhaps gained the most scholarly and mainstream attention in recent decades. On the other hand, Bruce Sterling's biot has not yet become widespread or well-understand as a concept. As people continue to create intimate, meaningful relationships with quantified self technologies and medical devices such as prostheses and sensors that are more continuously integrated with their bodies, these concepts might become further nuanced to account for a range of combinations of bodies and technologies.

Design Implications

In May 2011, new media artist James Bridle announced a Tumblr blog about an ongoing research project called the 'The New Aesthetic.' The blog attracted considerable attention among digital and scholarly elites from Bruce Sterling to Ian Bogost. According to Bridle, the blog features 'material which points towards new ways of seeing the world, an echo of the society, technology, politics and people that co-produce them. The New Aesthetic is not a movement, it is not a thing which can be *done*. It is a series of artefacts of the heterogeneous network, which recognises differences, the gaps in our overlapping but distant realities.' One of Bridle's projects, which defines the genre of The New Aesthetic, is titled 'The Iraq War: A Historiography of Wikipedia Changelogs.' The project is a 12-volume printed encyclopedia of all of the changes that were made to the Wikipedia article about the Iraq War. In late November 2013, the blog featured an image of a jigsaw puzzle of an anal sack of a double spined urchin from Science Photo Library (Bridle 2011).

A text that emerged from a writing-sprint in 2012, which intended to make sense of 'The New Aesthetic' referred to Bridle's examples as "something designed for network culture to take up: for him, the products are 'unknown,'" (Berry et al. 2012: 17). According to media theorist Ian Bogost, a leading advocate for a philosophical movement known as object-oriented ontology, The New Aesthetic does not go far enough in its ambition because it is primarily concerned with computation and digital things. Bogost argues that non-digital things such as

McDonald's perennial *McRib* sandwich are just as relevant as indications of the times in which we live.

These examples help to complicate the models and frameworks that are often used in human-centred design, which defines problems and needs at the intersection of people (desirable), technology (feasible) and business (viable) and seeks to create solutions to meet those needs. This is because none of these factors can be understood discretely as an input into a design process. Rather, in a world consisting of the cyber-urban, city-objects, object-bodies and city-bodies (or various interlinked meshes and mash ups that defy classification), it is necessary to create new design practices that transcend and transgress existing design frameworks.

Rather than continuing to use discrete categories (such as digital and material), computational metaphors (such as stack and layers) and, even, the overly used concept of generic hybrids, we must seek out language that truly allows us to comprehend the ways in which digital materiality is not merely a return to materialism but, in fact, a temporal and spatial reconfiguration that introduces a new set of digital-material actors at a variety of scales including the city, the object and the body (and their inter-minglings). These reconfigurations suggest terminology that acknowledges the ways in which the digital-material is liminal, in-between, lurking (seemingly invisibly) in the data shadows (Shelton et al. 2014) like digital ghosts and zombies that inhabit our cities.

Digital materiality is not a smooth hybrid that seamlessly integrates the digital world with the physical world. Rather it is characterized by seams (Chalmers/MacColl/Bell 2003), glitches (Nakamura 2013), conflicts and contradictions (DiSalvo 2012a; Hillgren/Seravalli/Emilson 2011), frictions (Kang/Cuff 2005) and disjunctures, which characterize the contextualized, embodied, lived experience of big data, smart cities, the 'internet of things' and the quantified self. In order to design for digital and networked media at these scales, it is necessary to exploit these tensions in what I call *design friction*.

By grappling with these challenges at a variety of scales, through prototypes, examples and experiments, it is possible to create a new lexicon for digital materiality that will allow us to transcend discrete categories. In thinking through the digital material, it is possible to imagine the ways in which we might come to new understandings that transcend other dichotomies as well. As such, it is possible to create a more pluralistic and diverse society (Escobar 2012).

Conclusion

Despite ongoing rhetoric around the integration of digital and physical realities in the mainstream media as well as in scholarly discourse, we seem to be stuck in a world of hybrids. Hybrids themselves have become a new kind of universal, which make it difficult to grasp the shaping and reshaping of digital and material phenomenon that we encounter constantly in everyday life in cities. Based on theories from science and technology studies, organizational science and examples from new media art and design, this paper argues for an integrated

theory of the cyber-urban that transcends current hybrid notions of digital materiality. In order to go beyond current discourses of hybrids, it is necessary to think across multiple scales and from multiple perspectives. This paper offers examples from Networked Cities, Networked Objects and Networked Bodies in order to illustrate the ways in which digital materiality is configured and enacted dynamically at a range of scales. In conclusion, this integrated theory of the cyber-urban is still 'in the making' in that with a greater proliferation of examples that complicate our understandings of discrete categories and existing hybrids, we will be able to more specifically name entities at the nexus of the city-object, the object-body, the city-body.

Acknowledgements

I am grateful to the Asia Research Institute at National University of Singapore for supporting the writing and presentation of an earlier draft of this paper, which was presented at a workshop on 'Conceptualizing Cyber-Urban Connections in Asia and the Middle East' in January 2014 in Singapore.

References

Arnall, Timo (2012): "Exploring 'Immaterials': Mediating Design's Invisible Materials." In: International Journal of Design 8(2), pp. 101-117.

Barad, Karen (2003): "Posthumanist performativity: Toward an understanding of how matter comes to matter." In: Signs 28.3, pp. 801-831.

Bean, Jonathan/Rosner, Daniela (2013): Taking the New Neologisms Offline. In: Interactions, 20(1), pp. 78-80.

Bell, Genevieve/Dourish, Paul (2007): "Yesterday's tomorrows: notes on ubiquitous computing's dominant vision." In: Personal and Ubiquitous Computing 11(2), pp. 133-143.

Bennett, Jane (2009): Vibrant matter: A political ecology of things, Durham, NC: Duke University Press.

Berry, David M. et al. (2012): New Aesthetic, New Anxieties. (http://v2.nl/publishing/new-aesthetic-new-anxieties).

Blanchette, Jean-François (2011): "A material history of bits." In: Journal of the American Society for Information Science and Technology 62(6), pp. 1042-1057.

Bleecker, Julian (2009): Design Fiction: A short essay on design, science, fact and fiction (www.nearfuturelaboratory.com/2009/03/17/design-fiction-a-short-essay-on-design-science-fact- and-fiction).

Bogost, Ian (2012): Alien phenomenology, or what it's like to be a thing, Minneapolis: University of Minnesota Press.

Bratton, Benjamin (2011): On the Nomos of the Cloud: The Stack, Deep Address, Integral Geography (http://bratton.info/projects/talks/on-the-nomos-of-the-cloud-the-stack-deep-address-integral-geography).

Bridle, James (2011): 'About'. Tumblr (http://new-aesthetic.tumblr.com/about).
Carey, James W. (1988): Communication As Culture: Essays on Media and Society, New York: Unwin Hyman.
Carlile, Paul R./Langley, Ann (2013): How Matter Matters: Objects, Artifacts, and Materiality in Organization Studies, Oxford, UK: Oxford University Press.
Chalmers, M./MacColl, I./Bell, M. (2003): "Seamful design: showing the seams in wearable computing", Paper presented at the Eurowearable.
Couldry, Nick/McCarthy, Anna (2004): Mediaspace: Place, Scale and Culture in a Media Age, London: Routledge.
Crabtree, Andy/Rodden, Tom (2008): "Hybrid ecologies: understanding cooperative interaction in emerging physical-digital environments." In: Personal and Ubiquitous Computing, 12(7), pp. 481-493.
Craig, David J. (2013): "Heady Collisions." In: Columbia Magazine (http://magazine.columbia.edu/features/summer-2013/heady-collisions).
DiSalvo, Carl (2012a): Adversarial design, Cambridge, MA: MIT Press.
DiSalvo, Carl (2012b): "Spectacles and Tropes: Speculative Design and Contemporary Food Cultures." In: The Fibreculture Journal 20, pp. 23-32.
Dourish, Paul/Mazmanian, Melissa (2011): "Media as Material: Information Representations as Material Foundations for Organizational Practice", Paper presented at the Third International Symposium on Process Organizational Studies, Corfu, Greece.
Dunne, Anthony (2001): Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design, Cambridge, MA: MIT Press.
Escobar, Arturo (2012): Notes on the Ontology of Design, Chapel Hill, NC: University of North Carolina Press.
Forlano, Laura (2009): "WiFi Geographies: When Code Meets Place." In: The Information Society 25, pp. 1-9.
Forlano, Laura (2013): "Making Waves: Urban Technology and the Coproduction of Place." In: First Monday 18(11) (http://firstmonday.org/ojs/index.php/fm/article/view/4968/3797).
Fors, Anna Croon/Wiberg, Mikael (2010): "Digital materiality as imprints and landmarks: The case of northern lights." In: International Review of Information Ethics 12(03) (http://www.i-r-i-e.net/inhalt/012/012-full.pdf).
Foth, Marcus (2008): Handbook of Research on Urban Informatics: The Practice and Promise of the Real-Time City, Hershey, PA: IGI Global.
Foth, Marcus/Forlano, Laura/Gibbs, Martin/Satchell, Christine (2011): From Social Butterfly to Engaged Citizen: Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement, Cambridge, MA: MIT Press.
Gibson, James J. (1977): "The theory of affordances." In: Robert Shaw and John Bransford (eds.), Perceiving, Acting and Knowing, New York: Wiley, pp. 67-82.
Gibson-Graham, Julie Katherine (2006): A postcapitalist politics, Minneapolis: University of Minnesota Press.

Gillespie, Tarleton/Boczkowski, Pablo J./Foot, Kirsten A. (2014): Media technologies: Essays on communication, materiality, and society, Cambridge, MA: MIT Press.

Gordon, Eric/Silva, Adriana de Souza (2011): Net locality: why location matters in a networked world, Malden, MA: Wiley-Blackwell.

Gross, Shad/Bardzell, Jeffrey/Bardzell, Shaowen (2014): "Structures, forms, and stuff: the materiality and medium of interaction." In: Personal and Ubiquitous Computing 18.3, pp. 637-649.

Haraway, Donna (1991): "A cyborg manifesto: science, technology, and socialist-feminism in the late twentieth century." In: idem., Simians, cyborgs and women: The reinvention of nature, London: Routledge, pp. 149-181.

Haraway, Donna (2003): The companion species manifesto: Dogs, people, and significant otherness, Chicago: Prickly Paradigm Press.

Haraway, Donna (2008): When species meet, Minneapolis: University of Minnesota Press.

Haraway, Donna (2011): "SF: Science Fiction, Speculative Fabulation, String Figures, So Far", Acceptance speech for Pilgrim Award, July, 7.

Hillgren, Per-Anders/Seravalli, Anna/Emilson, Anders (2011): "Prototyping and infrastructuring in design for social innovation." In: CoDesign, 7(3/4), pp. 169-183.

Humphreys, Lee. (2008): "Mobile Social Networks and Social Practice: A Case Study of Dodgeball." In: Journal of Computer-Mediated Communication 13(1), pp. 341-360.

Ito, Mizuko (2003): "Mobile Phones, Japanese Youth, and the Re-Placement of Social Contact. Front Stage – Back Stage: Mobile Communication and the Renegotiation of the Social Sphere" (http://www.itofisher.com/PEOPLE/mito/mobileyouth.pdf).

Juster, Norton (1961): The Phantom Tollbooth, New York: Random House.

Kitchin, Rob/Dodge, Martin (2011): Code/space: software and everyday life, Cambridge, Mass.: MIT Press.

Kuniavsky, Mike (2010): Smart things: ubiquitous computing user experience design, Boston, MA: Morgan Kaufmann Publisher.

Latour, Bruno (1992): "Where are the Missing Masses? A Sociology of Few Mundane Objects." In: Wiebe E. Bijker/John Law (eds.), Shaping Technology/Building Society. Studies in Sociotechnical Change, Cambridge, MA: MIT Press, pp. 151-180.

Latour, Bruno (1996): "On actor-network theory: a few clarifications." In: Soziale Welt 47, pp. 369-381.

Leonardi, Paul M. (2010): "Digital Materiality? How artifacts without matter, matter." In: First Monday 15(6) (http://firstmonday.org/article/view/3036/2567).

Mackenzie, Adrian (2010): Wirelessness: Radical Empiricism in Network Cultures, Cambridge, MA: MIT Press.

Munster, Anna (2006): Materializing New Media: Embodiment in information aesthetics, Hanover, NH: Dartmouth College Press.

Nakamura, Lisa (2013): "Glitch Racism: Networks as Actors within Vernacular Internet Theory", Culture Digitally//Examining Contemporary Cultural Production (http://culturedigitally.org/2013/12/glitch-racism-networks-as-actors-within-vernacular-internet-theory).

Orlikowski, Wanda J. (2007): "Sociomaterial practices: Exploring technology at work." In: Organization Studies 28(9), pp. 1435-1448.

Pinch, Trevor J./Bijker, Wiebe E. (1984): "The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." In: Social Studies of Science 14(3), pp. 399-441.

Porter, Michael E./Heppelmann, James E. (2014): "How Smart, Connected Products Are Transforming Competition." In: Harvard Business Review 92(11), pp. 64-88.

Ratto, Matt (2011): "Open Design and Critical Making." In: Paul Atkinson et al. (eds.), Open Design Now: Why Design Cannot Remain Exclusive, Amsterdam: BIS Publishers, pp. 202-209.

Robles, Erica/Wiberg, Mikael (2010): "Texturing the material turn in interaction design", Paper presented at the Proceedings of the fourth international conference on Tangible, embedded, and embodied interaction.

Robles, Erica/Wiberg, Mikael (2011): "From materials to materiality: thinking of computation from within an Icehotel." In: Interactions 18(1), pp. 32-37.

Rosner, Daniela et al. (2012): "From materials to materiality: connecting practice and theory in hc", Paper presented at the CHI'12 Extended Abstracts on Human Factors in Computing Systems.

Rosner, Daniela K./Ikemiya, Miwa/Kim, Diana/Koch, Kristin (2013): "Designing with traces", Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.

Shelton, Taylor/Poorthuis, Ate/Graham, Mark/Zook, Matthew (2014): "Mapping the data shadows of Hurricane Sandy: Uncovering the sociospatial dimensions of 'big data'." In: Geoforum 52, pp. 167-179.

Shepard, Mark (2011) (ed.): Sentient City: Ubiquitous Computing, Architecture, and the Future of Urban Space, Cambridge, MA: MIT Press.

Simon, Joshua (2013): Neomaterialism, New York: Sternberg.

Speed, Chris (2011): "An Internet of Things That Do Not Exist." In: Interactions 18(3), pp. 18-21.

Sterling, Bruce (2005): Shaping Things, Cambridge, MA: MIT Press.

Tsing, Anna L. (2005): Friction: An ethnography of global connection, Princeton, NJ: Princeton University Press.

Turner, Andrew (2006) Introduction to neogeography, Cambridge, MA: O'Reilly.

Wiberg, Mikael/Robles, Erica (2010): "Computational compositions: Aesthetics, materials, and interaction design." In: International Journal of Design 4(2), pp. 65-76.