xCoAx 2020
Computation,
Communication,
Aesthetics & X
2020.xCoAx.org
Graz, Austria

Open, Seamful and Slow: A More-Than-Human Internet of Things

Birgit Bachler
b.bachler@massey.ac.nz
Massey University, Wellington, New Zealand

Keywords: Networked Media, Internet of Things, More-Than-Human, Prototyping, Media Art.

Departing from the concept of an Internet of Things (IoT) as a means to give voice to non-human 'things', the project Wildthings.io seeks to develop experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions. This paper discusses the iterative design processes that concluded in the IoT artwork *Papawai Transmissions,* which imagines novel ways of understanding and (re-)connecting with disconnected streams, their communities and their ecosystems in urban Aotearoa/New Zealand, through methods of openness, seamfulness and slowness.

1. Introduction

In this paper, I discuss the iterative design processes of the research project Wildthings.io that concluded in the network installation *Papawai Transmissions*. With a focus on wai/water, the project set out to imagine novel ways of understanding and (re-)connecting with disconnected streams, their communities and their ecosystems in urban Aotearoa/New Zealand, specifically my place of residence, Te-Whanganui-a-Tara/Wellington. My fieldwork departs at a small stream in my neighbourhood, and fans out into the wider network of local freshwater which has largely disappeared from the cityscape. Data collected during fieldwork and lab development has informed the creation of electronic design artefacts to learn how the more-than-human world can inspire the development of networked media.

Departing from the concept of an Internet of Things as a means to give voice to non-human 'things', this research developed experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions. In this paper, I address a central question—how can we, as creatives, learn from the more-than-human world when building networked media—through three key sections. First, I engage with an overview of the term 'Internet of Things' and present early forms of networked objects. From here, I consider the development of a 'more-than-human' Internet of Things, and how such a concept could de-stabilise the Western anthropocentrism of previous IoT approaches. In the third section, I present a discussion of my research as realised through iterations of the network installation *Papawai Transmissions*.

1.1. The First "Things" on the Internet

The term 'Internet of Things' originated in 1999 at the Auto-ID Center at Massachusetts Institute of Technology. Kevin Ashton (2009), co-founder and executive of the Auto-ID Center, presented the idea of improving the efficiency of Procter and Gamble's supply chain management by connecting products via RFID technology to the Internet:

> "Adding radio-frequency identification and other sensors to everyday objects will create an Internet of Things, and lay the foundations of a new age of machine perception" (as cited in Santucci 2009, 2).

The idea of connecting objects to the Internet, however, is not entirely new. The first 'everyday' object connected to the Internet was a Coke machine at the Carnegie Mellon University Computer Science Department. The system, developed in 1982, remotely monitored the out-of-product lights on the machine's push buttons, and the status of each row of the vending machine could be queried through a terminal with the *finger* protocol. Users could retrieve three responses: `EMPTY`, a timer since the last refill, or, `COLD` in case the last refill was longer than three hours ago (see Everhart et al. 1990).

Another popular early networked object was the *Internet Toaster*, developed by John Romkey in 1990, presented at the Interop Internet Networking show in Las Vegas. The toaster could be controlled via TCP/IP and SNMP (Simple Network Management Protocol). One year after his first demonstration, Romkey added a robotic arm to the setup for loading the appliance with bread slices. In subsequent years, more experimental networked prototypes, such as the *Internet Weather Bear* were presented at the show.

The *Trojan Room Coffee Pot* from 1991 is also worth mentioning, as it shares a related interest into remote access to beverages, similar to the *Internet Coke Machine*. Developed at the University of Cambridge, England, the project evolved into what is now known to be the first webcam, showing a live image of a filter coffee machine pot. The researchers made the live image available on the World Wide Web, with the vision that anyone would be able to watch the coffee machine from anywhere in the world. Surprisingly, the site was hugely popular, and allegedly one of the most popular websites at the time.

In sum, these early IoT pieces were built as proofs-of-concept which made an appliance, and consequently the status of a beverage or piece of toast, remotely accessible for more convenient consumption. These early prototypes have inspired more experimental projects and sparked inspiration for networked art. The *Trojan Coffee Pot,* for example, whilst considered the world's first webcam, has also been discussed for its artistic qualities: for example as "telematic theatre" (Smith 2005) or as "identic art" (Alexenberg 2004).

1.2. The Art of Connecting Things: Some Artistic Encounters Explore Human/ Non-Human Networks

In contrast to the previously discussed networked explorations stands Natalie Jeremijenko's *Live Wire* or *Dangling String*, which is often referred to as the first Internet of Things artwork (Weiser and Brown 1996). The piece was developed during an artist residency at Xerox PARC, and described by Weiser and Brown as an eight-foot piece of plastic spaghetti that hangs from a small electric motor mounted on the ceiling, connected to an Ethernet cable. Every bit of information from the lab environment was translated into a motor movement so that with more network traffic, the sculpture would start becoming alive.

Playful explorations of how everyday objects could be connected to the Internet rose substantially during the 1990s, and networked artworks showed a growing tendency to technologically hybridise human and non-human modes of existence. One of the first notable networked art projects, which connected online users with plants, was *TeleGarden* from 1995. The art installation allowed web users to view and interact with a remote garden filled with living plants. Users could plant, water, and monitor the progress of seedlings by controlling an industrial robot arm. Their project thus

created a tension between the 'natural' living organic environment, and the 'unnatural' robotic arm interacting with it through remote, human commands (telegarden 2008).

The tensions this project speak to a broader project in which the category of 'human' itself increasingly comes into question. A decentering of the human, and a corresponding shifting of attention towards concerns for the non-human, can be found in a wide variety of recent and current western philosophical lines of thought (Grusin 2015, vii). This is a reaction to the predominant centring of the human in Western anthropocentrism, which some cultures, among them New Zealand Māori, have not adopted into their philosophies. The widespread interest in challenging the traditional divides between humans and non-humans has contributed to a growing push for methods that can work with the distributed knowledges, experiences and values of a more-than-human world.

Human-Computer Interaction (HCI) have shown increasing interest in this decentering, particularly as a "response to concerns about environmental sustainability, technology obsolescence, and consumerism" (Bardzell et al. 2019). Greenhough (2014) claims that natural disasters and an increased spread of zoonotic diseases are urging Western societies to shift their focus away from the human towards the non-human (94). The major human impact on earth and atmosphere at a global scale has resulted in the proposal of naming the current geological epoch the "Anthropocene" (Crutzen and Stoermer 2000). Haraway (2015) demands that it is "our job, to make the Anthropocene as short/thin as possible and to cultivate with each other in every way imaginable epochs to come that can replenish refuge" (160). Notably, these Anthropocene-related urgencies, among them the looming climate crisis, have been voiced by indigenous peoples long before western discourse has acknowledged them.

2. Prototyping Methods for a More-Than-Human IoT

The search for methods involving the decentering of the human help to establish a theoretical grounding for design research that aims to navigate this complex territory, with the aim to introduce new perspectives to the development of an Internet of Things. My research, as situated in Aotearoa/New Zealand, presented further opportunities for engaging in a methodological approach which responds to this call for a diversity of perspectives in design research. As a European born researcher, only having lived in New Zealand for five years, I need to learn about local, situated knowledges (Haraway 1988) and perspectives. Working within the context of Aotearoa/New Zealand offered rich learning opportunities when there is already a culture present, where a Māori worldview offers a deep, intricate understanding of 'thing' networks.

From a designer's perspective, new, more malleable and open frameworks for approaching research problems are hence emerging, among them post-qualitative research (Lather and St. Pierre 2013) and non-representational approaches (Vannini 2015). However, given that they are still in their infancies, these new, cross-cultural traditions face many challenges when trying to weave diverse attributes and non-text focused work into Western academic publishing structures, where they might be described as "messiness" (Law 2004), or "slowness" (Ulmer 2017)." These factors, in turn, have become core to my research paradigm where, as I outline below, slowness, seamfulness, and openness have been integral to the development of a networked artwork as part of Wildthings.io.

2.1. Opening the Design Process to More-Than-Human Voices

From the outset of the research, I considered Participatory Design (PD) as an avenue to involve the more-than-human world into the research process as participants. This required unpacking of what participation means in a more-than-human context, and if and how traditional human-centred participatory design methods can provide new perspectives on designing with and for water and connected ecosystems.

> "It takes work, and new ways of thinking, and new kinds and methods of openness, to bring substantively new voices into a conversation." (Muller 2009, 166)

The opportunities and challenges of adding new voices and perspectives into a design conversation are widely discussed in the field of Participatory Design (see for example Bannon and Ehn 2012; Kensing and Greenbaum 2012). A more-than-human participatory research agenda, as described by Bastian et al. (2016), supports the inclusion of marginalised voices in the research process, and "makes research accountable to those it affects" (5). Nonetheless, in finding myself working with local communities and ecosystems in an Aotearoa/New Zealand context, it is also vital to acknowledge and incorporate non-western traditions and modes of thought (see Smith 2012). Blomberg and Karasti (2012) discuss the opportunity to include ethnographic sensibilities into a PD approach but warn that:

> "We should not assume that the tools and techniques of Participatory Design developed for Scandinavian (and other European and North American) audiences will enable multiple voices to define and inform the design when transported to very different traditions." (Blomberg and Karasti 2012, 107)

As an artist, designer, coder and researcher taught within Western academia, most of my tools and technologies stem from a Western background. I must avoid a technological colonisation of Aotearoa's more-than-human worlds through my research and the tools I develop.

In the "perhaps the most quoted sentence in the book" (Smith 2012, xi) one which stands central at the opening to the work of Decolonizing Methodologies, Smith reminds us:

> "From the vantage point of the colonised, a position from which I write, and choose to privilege, the term 'research' is inextricably linked to European imperialism and colonialism. The word itself 'research', is probably one of the dirtiest words in the indigenous world's vocabulary." (Smith 2012, 1) "

I need to be humble and acknowledge the privilege of doing research with and for the water of the streams of Aotearoa/New Zealand. Similarly, I need to scrutinise my background in Open Source development and keep assessing if and how open sharing of my design research benefits the more-than-human communities it affects. An openness to share my process and give the knowledge back to communities who care for their streams implied open licensing and publishing of hardware, software, writings and recordings of my design processes. Whilst it is not within the scope of this article to fully unpack the complexities and tensions which can arise from mobilising 'Open' culture into spaces grappling with the implications of decolonisation, emergent work in this field reminds us that as researchers, we must always be critically aware that underlying much 'Open' discourse' is the assumption of the universality of knowledge systems, often dictated by hegemonic knowledge groups (see for example Adam et al. 2019). I take up this approach to openness in my own work with this caution in mind. Besides the effort to be attentive to more-than-human voices, openness has also been embraced in the design process itself, through the concept of 'beautiful seams', which I discuss in the following section.

2.2. An IoT of Beautiful Seams

When Mark Weiser (1991) envisioned the computer of the 21st century, he described an environment in which networked computers of various sizes and forms vanish into the background. In his vision, machines resided in the human world and posed no barrier to physical interaction like the then-popular desktop computer:

> "Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods." (Weiser 1990)

In later talks, Weiser (1994; 1995) addressed the misleading concept of seamlessness, and argued for "seamful systems", with "beautiful seams". Weiser also rejected the idea of an interface as a boundary or difference and argued that the unit of design should involve social people, in their environment plus their device (Weiser 1995, 21). Later, Chalmers and MacColl (2003) argued for seamfulness in design and described it accordingly:

> "taking account of the finite and physical nature of digital media. Seamful design involves deliberately revealing seams to users, and taking advantage of features usually considered as negative or problematic"
> (Chalmers and MacColl 2003, 1).

Chalmers et al. (2003) pointed out that the revealing of the seams in the infrastructure of Ubiquitous Computing can be an opportunity for user understanding and empowerment. Seams could also be a way towards the creation of more dynamic systems, that are able to adjust to interaction patterns originally not envisioned by the designer.

Seamlessness in IoT devices is problematic not only in terms of privacy concerns but also in relation to obfuscating functionality to users, preventing understanding of what networked devices really do, at any given point in time. Seamful design tries to "reveal inevitable seams in ubicomp systems and use them to increase awareness for system infrastructures, their heterogeneous components and otherwise neglected yet useful information within the system" (Broll and Benford, 155). Inman and Ribes (2019) consider seamful and seamless design as complementary concepts and consider "beautiful seams" as

> "a phrase that seems to capture both the spirit of user-friendly, coherent design emphasised by seamlessness and the heterogeneity, contingency, and appropriability of seamful design."
> (Inman & Ribes, 2019, 12).

The embracing of seamful design requires slowing down and taking time to acknowledge rough edges as a feature of a design piece. This slowness, however, gives access to discovering qualities of design that might go unnoticed within a fast, optimised development cycle.

2.3. Slowness

> "Slowness is a process of unlearning and unsettling what has come before." (Springgay and Truman 2019, 15)

Before developing devices for an environment, it was also necessary to take time to reveal and learn about existing networks before designing new nodes and connections. By advocating for a 'Slow Ontology', Ulmer (2017) describes how, in new materialist qualitative scholarship, a more-than-human, entangled approach to research involves the writing of environmental landscapes, as well as writing on/with/through/in aspects of nature (207), calling for more-than-methodologies which "involve material, ecological, and temporal inquiries" (Ulmer 2017).

An approach to slowness when working with more-than-human ecologies resonates with how Pigott and Lyons (2016) discuss their artistic practice as a

> "[...] slow attunement and creative 'listening'. This process involved a distillation of a rhizomic mesh of conversations and encounters, embracing place identity, species, technology and communication" (144)

Embracing slowness also afforded time to understand what it means to be a designer in Aotearoa/New Zealand. Slowness allowed me to pause and take the time to acknowledge that research and knowledge production have been part of this land centuries before the establishment of the university and academia. The inclusion of more-than-human concerns into research methodologies has been central to Te Ao Māori (the Māori world) and Mātauranga Māori (the Māori way of engaging with the world) long before academia started to turn attention away from anthropocentrism.

These considerations, alongside seamfulness and openness, guided the creation of a range of design outputs along the research journey. At the heart of development sits a series of networked installations collected under the title Wildthings.io.

3. Wildthings.io: Sensing Streams

As part of my creative research with Papawai Stream and Moturoa Stream in Pōneke/Wellington, I developed experimental prototypes for a more-than-human IoT network. These consist of a range of DIY electronic nodes as artistic interventions, collectively created and published as Wildthings.io. The installations *Moturoa Transmissions* and *Papapwai Transmissions* contain a collection of low-cost, Internet of Things network prototypes for engaging with local stream environments. The stand-alone Wi-Fi networks, installed at streams in Pōneke/Wellington, consist of several modular DIY Wi-Fi nodes that capture, visualise, and sonify data such as electric conductivity, temperature, and turbidity. The networks aided the imagination of novel ways of (re-)connecting with disconnected waters and their more-than-human ecosystems.

Prototypes for the network were developed in response to field immersions, walking conversations, lab prototyping, test installations and exhibitions, presentations, and publications. From the outset of the prototyping process, I developed tentative parameters to evaluate my design outputs against, ranging across theoretical, artistic and technical considerations. While I started with a larger, and more detailed and specific set of parameters to work with, three categories expressed the character of my research journey across data collection, generative design research and evaluation. At first glance, openness, seamfulness and slowness appear as shortcomings or hindrances to creative development—especially from the perspective of a technology industry where quick development cycles, seamless solutions and prototype development towards exit strategies are idealised. In this final section, I introduce the iterative development process of the IoT artworks as part of Wildthings.io and conclude with a discussion of highlighted methods.

3.1. Encountering the Stream: Moturoa Transmissions

The first-exhibited iteration of the network was installed during the Brooklyn Arts Trail at Moturoa Stream in Pōneke/Wellington under the title *Motuora Transmissions*. The installation featured one Raspberry Pi with an external USB antenna serving a local Wi-Fi network and acting as an MQTT broker for the Wi-Fi nodes. The nodes consisted of Wemos D1 boards and custom hardware monitoring the stream environment through a range of environmental sensors, a mix of off-the-shelf shields and DIY sensor solutions. The artwork was operating during daytime and disassembled for charging overnight, and accompanied by an artist statement:

> “A networked series of interventions in the surrounding environment of Moturoa Stream that senses and monitors change in a range of variables, such as temperature, humidity and conductivity. Together the stations enter a conversation beyond their mere weather-reflective qualities and given structure of land, water and its human and non-human encounters to form a visually engaging addition to the ecosystem in which they are situated.”

The inclusion of an early prototypical rendition of the work in a public art exhibition provided an opportunity for audience feedback and allowed quick iterations and updates of hardware and software overnight. The piece was installed close to a secondary entrance of Central Park, where Moturoa Stream is not directly visible but—unbeknownst to many locals—emerging from an underground pipe. Hidden from sight behind thick foliage, the stream water cascades from the pipe outlet into a small plunge pool, before making its way down through the park before being piped underground again. The selected location intended to highlight the transition the water made between the ontological categories of ‘stormwater’ and ‘stream’. However, the site also obfuscated an apparent connection between the exhibited electronic artefacts and the stream, without providing further context to an audience. One of the nodes placed close to the accessible path, visualised the local network traffic and the sending and receiving of data through a multi-colour LED. An additional node, recording sensor data to a memory card, was added on day two after feedback from the audience.

Initial challenges for the exhibit included outdoor-proofing of the network and providing reliable power to all nodes. The hardware design needed to be suitable for exhibition across multiple days under variable weather conditions, protecting components and circuitry against more-than-human forces such as moisture, wind and heat. The exhibited design re-used water bottles initially used for collecting stream samples and testing DIY nodes in the lab as casing. The transparent casing gives an audience visual access to all componentry and reveals the processes and connections that went into the assembly of the hardware.

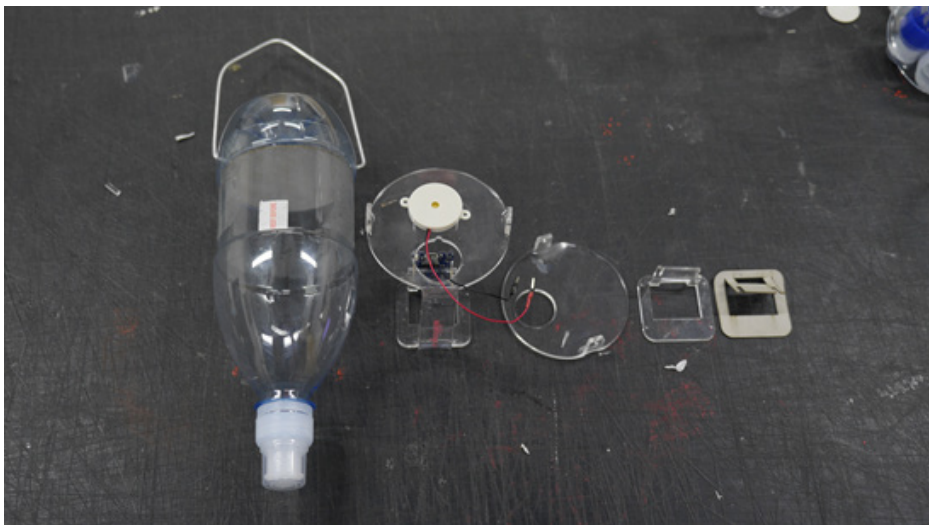

Fig. 1. Iterative prototyping of a recycled outdoor-proof project enclosure for a microcontroller and a power bank.

The recycling of used water bottles as outdoor-proof project enclosures, instead of manufacturing new materials, resonated with a low-cost and low-impact approach to prototyping. The casing also connected back to a range of discarded bottles I encountered during my fieldwork, emerging from muddy stream beds after heavy rainfall. A disadvantage of the material, however, was that it slowly degenerated and cracked from continuous de-assembling and re-assembling of the nodes for charging and maintenance.

Fig. 2. Installation at Moturoa Stream showing two sensor nodes and Wi-Fi Access Point/MQTT Broker.

While the schedule of the public art event pushed the development of the project significantly forward within a few weeks, the compressed timeframe of quick iterations developed overnight based on feedback from the audience came with a few drawbacks. Having some of the artefacts tested in the field for the first time during the exhibition was stressful, and demanded some on-location debugging. Some of these field updates were not appropriately documented in the online code repository due to the lack of Internet access on location.

3.2. Prototyping Slow Iterations: Papawai Transmissions

The development of *Papawai Transmissions* was set at a stream in a different suburb of Pōneke/Wellington, and was based on previous design outputs and outcomes of *Moturoa Transmissions*. With no fixed exhibition schedule, the oscillations between fieldwork and lab development provided more opportunities for experimentation and productive failure. While the basic network design with the Raspberry Pi hub node at heart remained the same, a variety of additional nodes were developed and updated in response to feedback from invited participants, among them individuals from local DIY electronics, arts, and stream restoration community groups. Modified glass jars replaced outworn bottle enclosures, and previously laser-cut acrylic inlays were simplified in the form of paper and cardboard pieces.

Fig. 3. Labwork: Prototype of an LED node with paper and copper tape.

A notable addition to the *Papawai Transmissions* network was bespoke nodes that would visualise incoming sensor data through LEDs or sonify it, translating changes to the stream environment into sound. While sensor nodes would be placed beside the stream, the outputting nodes could be placed closer to accessible paths at viewable height for an audience.

The network was designed to connect a human audience in various ways to the streams: First, the installation could be encountered in the wild and investigated by an audience at their own pace. Simple labels on the nodes would help identify nodes and their inner workings. Second, the installation was also aimed at an audience who would be invited to help install the work and learn about the technology behind it, while spending time with the nodes and the stream in the wild. Audience feedback also indicated the interest in self-guided walks and installations of probes along the stream. This approach opens possibilities of adding a field notebook to the artwork, in which human participants can add their own narratives to the sensor

data by recording their observations, e.g. by adding paper notes to the kit which could be included in the project enclosures. Finally, the online repository contains code and schematics of all Wildthings.io nodes, and invites developers to use the setup as is, or modify the work to suit their own stream environments and re-share with their communities.

Fig. 4. Fieldwork: testing and debugging of revised sensor nodes at Papawai Stream.

4. Conclusion

This paper has discussed how, through embracing methods of openness, seamfulness, and slowness, the project Wildthings.io has sought to respond to the question of how we, as a design community, can learn from the more-than-human world when building networked media. Via the development of experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions, this research departed from the concept of an Internet of Things as a means to give voice to non-human 'things'.

With a focus on wai/water, the design of the networked installations discussed here specifically engaged with local stream ecologies in Pōneke/Wellington that have largely disappeared from the cityscape and have been piped underground due to urban development. Data collected during fieldwork and lab work has informed the creation of electronic design artefacts to learn how the more-than-human world can inspire the development of networked media, and to imagine novel ways of (re-) connecting with disconnected waters and their more-than-human ecosystems. Doing so calls into focus the role design plays within a growing push for methods that can work with the distributed knowledges, experiences and values of a more-than-human world.

Acknowledgements: First of all, I would like to thank all generous participants who contributed their time and knowledges to this research project. I would like to express my sincere gratitude to my doctoral supervisors Dr Anne Galloway and Prof Sally Jane Norman, for their continuous encouragement, support and thoughtful advice throughout my research journey. I am grateful to my colleagues, especially research coordinator Dr Catherine Hoad, for engaging in and providing critical feedback on my work. I would like to thank the anonymous reviewers of this article who provided valuable comments and helpful suggestions.

References

Adam, Taskeen, Maha Bali, Cheryl Hodgkinson-Williams, and Tannis Morgan.
2019. "Guest blog – Can we decolonise OER/Open? #DecoloniseOpen", OER 2019. Accessed May 3, 2020. https://oer19.oerconf.org/news/blog-can-we-decolonize-oer-open-decolonizeopen/#gref

Alexenberg, Mel.
2004. "Semiotic redefinition of art in a digital age." In Semiotics and Visual Culture: Sights, Signs, and Significance, edited by Debbie Smith-Shank, 124-131. Reston, VA: National Art Education Association.

Ashton, Kevin.
2009. "That 'internet of things' thing." RFID journal 22, no. 7: 97-114.

Bannon, Liam J., and Pelle Ehn.
2012. "Design: design matters in Participatory Design." In Routledge International Handbook Of Participatory Design, edited by Jesper Simonsen and Toni Robertson 57-83. New York: Routledge.

Bastian, Michelle, Owain Jones, Niamh Moore, and Emma Roe.
2016. "Introduction: More-than-human participatory research: Contexts, challenges, possibilities." In Participatory Research in More-than-Human Worlds, edited by Michelle Bastian, Owain Jones, Niamh Moore, Emma Roe, 15-30. New York: Routledge.

Bardzell, Jeffrey, Shaowen Bardzell, and Szu-Yu Cyn Liu.
2019. "Beautifying IoT: The Internet of Things as a cultural agenda." In Social Internet of Things, edited by Alessandro Soro, Margot Brereton, Paul Roe, 3-21. Springer, Cham.

Blomberg, Jeanette, and Helena Karasti.
2012." Ethnography: Positioning ethnography within participatory design." In Routledge International Handbook Of Participatory Design, edited by Jesper Simonsen and Toni Robertson, 106-136. New York: Routledge.

Broll, Gregor, and Steve Benford.
2005. "Seamful design for location-based mobile games." In International Conference on Entertainment Computing – 4th International Conference Proceedings, edited by Fumio Kishino, Yoshifumi Kitamura, Hirokazu Kato, Noriko Nagata, 155-166. Springer: Berlin, Heidelberg.

Chalmers, Matthew, Ian Maccoll, and Marek Bell.
2003. Seamful Design: Showing the Seams in Wearable Computing, in International Conference Proceedings, Eurowearable 2003, edited by Sandra I. Woolley and Chris Baber, 11-16. Birmingham, UK. https://doi.org/10.1049/ic:20030140.

Chalmers, Matthew, and Ian MacColl.
2003 "Seamful and seamless design in ubiquitous computing." In Proceedings of Ubicomp 2003 Workshop at the crossroads: The interaction of HCI and systems issues in UbiComp, 577-584, Seattle, Washington.

Crutzen, Paul J.
2006. "The 'Anthropocene.'" In Earth System Science in the Anthropocene, edited by Eckart Ehlers and Thomas Krafft, 13–18. Springer: Berlin, Heidelberg. https://doi.org/10.1007/3-540-26590-2_3.

Everhart, Craig, Caplan Eddie, and Nichols David.
1990. "Coke.History.Txt." Accessed May 3, 2020. http://cseweb.ucsd.edu/~bsy/coke.history.txt.

Greenhough, Beth.
2014. "More-than-human geographies." The SAGE Handbook of Human Geography, edited by: Roger Lee, Noel Castree, Rob Kitchin, Victoria Lawson, Anssi Paasi, Chris Philo, Sarah Radcliffe, Susan M. Roberts, Charles W.J. Withers, 94-119. London: SAGE.

Grusin, Richard (ed).
2015. The Nonhuman Turn. Minneapolis: University of Minnesota Press.

Inman, Sarah, and David Ribes.
2019. "'Beautiful Seams': Strategic Revelations and Concealments." In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19, 1–14. Glasgow: ACM Press. https://doi.org/10.1145/3290605.3300508.

Haraway, Donna.
1988. "Situated knowledges: The science question in feminism and the privilege of partial perspective." Feminist studies 14, no. 3: 575-599.

Haraway, Donna.
2015. "Anthropocene, capitalocene, plantationocene, chthulucene: Making kin." Environmental humanities 6, no. 1: 159-165.

Kensing, Finn, and Joan Greenbaum.
2012. "Heritage: Having a say." In Routledge International Handbook of Participatory Design, edited by Jesper Simonsen and Toni Robertson, p41-56. London: Routledge.

Lather, Patti, and Elizabeth A. St. Pierre.
2013. "Post-Qualitative Research." International Journal of Qualitative Studies in Education 26, no. 6: 629–33. https://doi.org/10.1080/09518398.2013.788752.

Law, John.
2004. After Method: Mess in Social Science Research. London: Routledge.

Muller, Michael J.
2007. "Participatory design: the third space in HCI." In The Human-Computer Interaction Handbook, edited by Andrew Sears and Julie A. Jacko, 1087-1108. Boca Raton: CRC Press.

Pigott, Jon, and Antony Lyons.
2016. "Shadows, undercurrents and the Aliveness Machines." In Participatory Research in More-than-Human Worlds, edited by Michelle Bastian, Owain Jones, Niamh Moore, Emma Roe, 155-174. New York: Routledge.

Santucci, Gérald.
2009. "From internet of data to internet of things." In Proceedings From International Conference On Future Trends Of The Internet, 1-19, Luxembourg.

Smith, Barry.
2005. "Jennicam, or the telematic theatre of a real life." International Journal of Performance Arts & Digital Media 1, no. 2: 91-100.

Smith, Linda Tuhiwai.
2012. Decolonising methodologies: research and indigenous peoples. Dunedin: University of Otago Press.

Springgay, Stephanie, and Sarah E. Truman.
2017. Walking methodologies in a more-than-human world: WalkingLab. New York: Routledge.

telegarden.
2008. Telegarden Description. Accessed May 3, 2020. https://www.youtube.com/watch?v=gbyy5vSg8w8.

Ulmer, Jasmine B.
2017. "Writing slow ontology." Qualitative Inquiry 23, no. 3: 201-211.

Vannini, Phillip (ed).
2015. Non-representational methodologies: Re-envisioning research.
New York: Routledge.

Weiser, Mark.
1991. “The Computer for the 21st Century.” Scientific American 265, no. 3: 94-105.

Weiser, Mark.
1994. “Ubiquitous computing.” In Proceedings of the 22Nd Annual ACM Computer Science Conference on Scaling Up: Meeting the Challenge of Complexity in Real-world Computing Applications, edited by John Werth and Laurie Werth, ,418-420. https://doi.org/10.1145/197530.197680

Weiser, Mark.
1995. “Ubiquitous Computing.” Presented at the Usenix Association Technical Conference, New Orleans, LA, United States, January 18. http://www.ubiq.com/hypertext/weiser/Usenix95Slides.ps.

Weiser, Mark, and John Seely Brown.
1996. “Designing calm technology.” PowerGrid Journal 1, no. 1: 75-85.