Inarticulate Devices: Critical Encounters with Network Technologies in Research Through Design

Cally Gatehouse
Northumbria University
Newcastle upon Tyne, UK
cally.gatehouse@northumbria.ac.uk

David Chatting
Goldsmiths, University of London
London, UK
david.chatting@gold.ac.uk

ABSTRACT
Research through design (RTD) is commonly conceived as a material and discursive practice of articulating knowledge. This paper contributes to the understanding of RTD as a form of critical inquiry by considering how inarticulacy can also be a productive element of this process. We present two reflective accounts of critically-engaged RTD practices in which our attempts to articulate concerns or questions were met with resistance from technology that was both the subject and medium of our investigation. We argue that encountering inarticulacy is not a failure of RTD but instead points to how material exploration can sensitise us to how network technology resists articulating certain values or concerns. Encountering inarticulacy led us to formulate new problems and new lines of inquiry. We conclude by suggesting that the central role given to ambiguity in RTD prepares us to witness and respond to inarticulacy in our practices, design outcomes and critical understandings.

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Research Through Design; Networks; Critical Design; Adversarial Design; Hacking; STS

CSS Concepts
- Human-centered computing ~ Interaction design ~ Interaction design process and methods

UNSETTLING THE NETWORK

Critical design is a practice oriented towards problem making rather than problem solving [19]. The potential for this reorientation to form the basis of critical inquiry has been long recognised [42] and in recent years there has been a growth in accounts of critical design research that provide an empirical and theoretical underpinning for these practices as a distinctive research methodology [16,25,48]. This paper contributes to this body of work by presenting two situated accounts of how problems get made through material exploration with network technology. Specifically, it examines how our practices brought us into contact with inarticulacy in ways that were productive of new problems. In doing this, we contribute not only to a refined understanding of how problems get made through critical practice but also identify how design research's long-standing engagement with ambiguity has a potential to be a vital component of design research practice that answers Haraway's call to 'stay with the trouble'. [34]

This paper brings together accounts of two research practices that are both concerned with the way that network technologies reconfigure the boundaries between public and private realms. These programmes of inquiry are independent of each other and possess distinct focuses: mine (Gatehouse) is concerned with *networked public space*, while Chatting's is centred on *domestic networked devices*. However, while the work discussed here is not conducted as a formal collaboration, our practices are in dialogue through on-going discussions, mutual support and a shared studio space. This dialogue is often centred on how we have both used network technology as a means to investigate network technology as part of our research driven design practices.

Our work seeks to examine the social, material and cultural role of networked technology by making interventions into the network technologies. Such practices could be understood as part of a wider materialist turn in critical thinking about the physical structures that shape networked technology [39]. This concern with 'rematerialising' the digital is in part an attempt to move beyond a material-digital binary opposition that not does not reflect the experience of using or designing ubiquitous network technology [49]. However, it is also a critical project which aims to reveal the hegemonic systems hidden by rhetorical devices like 'the cloud' that obscure how the materiality of networks shape and distribute power.

Concepts like 'the cloud' black-box network technology in both the engineering sense that the inner workings of a system are not visible, but also the sense employed in Actor Network Theory (ANT). In ANT, black-boxing is a social process through which something becomes uncontested [44]. 'A black box contains that which no longer needs to be reconsidered, those things whose contents have become a matter of indifference' [12:285]. Things that are black boxed resist being understood as issues for concern because they appear to be uncontestable, or natural parts of the world.

In both of our practices, we used design as a means to probe network devices as black boxes, in both senses. We sought to make the network infrastructure legible to ourselves and

other as a means to imagine how the network could be materialized *differently*. In this manner, we share an approach exemplified by James Bridle when he described his work as being "undertaken within its own medium: it is an attempt to 'write' critically about the network in the vernacular of the network itself" [9]. In pursuit of this, we used mundane interactions with technology like joining WiFi or observing a Kindle lock screen as a starting point for an inquiry into the ways that network technology shapes our lives, and as a means to consider how it could shape them differently.

CRITICAL DESIGN AS INQUIRY

Our practices are part of the broader tradition of critical practices that use design as a form of *problem making* rather than problem solving. These practices have often been conceptualized as a form of inquiry (e.g. [2,58]) albeit one that is outside, or on the margins of, formal academic research. However, with the growth Research Through Design (RTD) methodologies [20,27,29], these critical practices have found a new home within mainstream academic practices. While this has provided new opportunities and resources for critical design, working within formal academic discourses has also brought greater methodological scrutiny. For instance, critical design practices often position themselves as engaging with publics through making designed interventions that aim to provoke debate or discussion. However, beyond rhetorically positioning such work as 'for' debate, critical designers have rarely given an empirically- or theoretically-grounded account of how such provocations result to public engagement [38]. The result is a gap between knowing what designers would like their work to do and knowing what their work actually does when it comes into contact with publics.

Carl DiSalvo's concept of Adversarial Design [16] is one model of design as critical inquiry that seeks to address this methodological gap. Drawing on the works of John Dewey, Bruno Latour, and Chantal Mouffe, DiSalvo has developed an account of how design can enable publics to form, and developed an empirical approach for studying this practice. In DiSalvo's account, design can give form to 'issues' around which publics can gather [18]. For instance, by designing tools for visualizing and sharing pollen levels, individual experiences can become a shared matter for discussion and action for those concerned. DiSalvo identifies a range of tactics by which design can make latent issues sensible, and perhaps the most pertinent to our practices is that of articulation.

DiSalvo is here building upon the term 'articulation' in a number of senses, firstly as a political process of making connections to produce new forms of discourse and practice. In doing this, DiSalvo draws on Latour's theorisation of a political process centred on forming collectives through articulation [40]. DiSalvo adds to this the additional sense of articulation used to describe the physical engineering of joints and joins. By bringing these different senses of articulation together, DiSalvo considers how in making networked devices we can articulates issues through making material and discursive joints. By making new connections and reconfiguring existing ones, such devices create a 'collective of sorts that people can participate in to consider and question the components of this system and their relations' [16:113]. Key to this is not only making certain connections visible and sensible, but making it possible to consider the consequence of making other connections.

This idea of articulation gives shape and focus to a critical design as material-discursive practice, beyond rhetorical appeals to 'design for debate'. It also gives a frame of reference for criticality beyond the models of critique that reduce critical design to an applied branch of the Frankfurt School [48]. DiSalvo's vision is for a critical practice that answers Latour's call for the critic to be 'not the one who debunks but the one who gathers' [41:264] and in doing so opens a path towards a more participatory mode of critical design [17]. As well as providing a stronger basis for claims regarding design's potential for forming publics, this account also leads to a firmer sense of how these practices might be understood as research. And it has been influential in framing recent work in interaction and participatory design concerned with engaging publics (e.g. [14,36,37]).

In particular, DiSalvo finds a parallel between the material articulations and Dewey's notion of inquiry as a process through which "the elements of a situation are discovered, analysed, and synthesized into a new whole — a coherent object or event that has a perceivable structure and significance." [16:116]. However, in this paper we present two accounts of our experiences of designing with network technology which complicate this account of design as inquiry. We set out to make or remake network devices in response to reflecting upon our own experiences of them. By doing this, we hoped to make an object that could share these reflections in a compelling and coherent way. Both of us start our stories with a clear sense of the kind questions and values we wanted to articulate with our devices. However, as our inquiry proceeded the opposite happened. Things became less coherent, objects and events became harder to understand, their structure and significance more obscure. Rather than making the 'messy elements of a situation into an object and experience that allow one to sense it and make sense of it' [ibid:118], things became harder to understand or make sense of. In fact, to some extent we still can't fully make sense of the situation. As we retrace our steps through notebooks, draft papers, git repos, code, sketches, publications, objects and images, we often find ourselves disoriented all over again.

THIS IS NOT A PAPER ABOUT FAILURE

However, we would like to suggest that what follows is not a case of design research failing. If anything it is a case of it working too well. Rather than a terrible failure of inquiry, we have come to think that the disorientation we experienced as a result of encountering inarticulacy is an important part of

design research as critical inquiry. As such, what follows is *not* a paper documenting failure of design research in the tradition of Gaver et al.'s 2009 *Anatomy of a Failure* paper [30]. Instead, we wish to argue that because the practice of design research brings us into contact with the unsettling, the inarticulate and the incoherent it is a valuable and compelling form of critical inquiry.

Viewing inarticulacy as not just as a raw material to be processed into knowledge or an unfortunate by-product of our practice would seem to take us in the opposite direction of travel to most RTD. To become articulate is a central aspiration of design as a research practice. Like many practice-based methodologies, RTD begins from a perceived failure of design and designers to speak for themselves. Schön's influential book *The Reflective Practitioner* is rooted in the 'assumption that competent practitioners usually know more than they can say' [52:8]. In recent years, this has been expanded to include material, visual and verbal forms [46]. However, the idea that RTD is process of articulating knowledge remains prevalent.

As the gap between our experiences and DiSalvo's account of critical practice hints, the assumption that research is straightforwardly a process of becoming more articulate might not fully account for how critical design research makes problem. Perhaps the reason for this can be traced back to one of the foundational tenants of critical design: that it is practice oriented towards producing problems rather solutions [19]. Hauser *et al.* [35] have documented the ways in which conventional human centered-design research methodologies are not always a good fit for non-utilitarian design practices. Similarly, in framing these practices as research, we need to understand that critical design as inquiry might require us to rethink how and what we are articulating in critical design as a research methodology.

The question then becomes what are the methodological consequence of aiming to articulate a problem rather than a solution? To begin to answer this question, we have looked to Mariam Fraser's conception of research as a form of 'inventive problem-making'. For Fraser, the aim of such research 'is not to solve a problem, or to explain it away but rather to try to enable it to "speak" or to pose it in terms that enable it to play itself out in productively creative ways' [26:78]. So, just as critical design does not propose solutions, research framed in this way does not produce knowledge in the form of answers or explanations, but in new ways of asking questions. As well as the obvious parallels between this framing of research and critical design practice, Fraser's proposal for research as 'inventive problem-making' is helpful in identifying the potential value in encountering inarticulacy.

To begin, we need to depart slightly from Latour's (and by extension DiSalvo's) view of the role of the critic as 'one who assembles'. Fraser asks what if 'the critic was obliged to attend not only to those entities that are physically or conceptually present somewhere (just not here), but to virtual multiplicities or singularities that have no corporeal presence at all.' [Ibid:71]. This question shifts the focus from what has been articulated, to the process of articulation, and by extension, to that which resists or refuses articulation. For Fraser, events offer us a way to become oriented towards these processes and our place within them. This idea of 'event thinking' as an orienting device has been put to productive use by STS scholar Mike Michael, in conjunction with Stengers' figure of *the idiot.* Stengers' idiot is a conceptual figure, a non-participant in events who cannot or will not explain their non-participation [55]. Michael describes the idiot as persistent inarticulate presence which haunt events and meaning making. The idiot won't (and can't) tell us why they don't join the collective, and so, by noticing the idiot's presence, we become aware that the current way things have been articulated is not the only possibility.

These concepts provide a basis for identifying the potential for a productive role for inarticulacy in design research. This combination of event thinking, and the conceptual figure of the idiot as a has had a central role in the development of speculative research that, rather than using design techniques for creating future visions, constructs 'adequate concepts and devices for exploring possible latent futures that matter' [59:347]. The idiot has also been used as a means to examine the role of the non-participant in Participatory Design [50]. In this paper we wish to extend these discussions by examining the ways in which non-human elements can resist or refuse to participate in design research in order to provide a situated account of the critical elements of our research practices.

THIS IS A PAPER ABOUT MAKING PROBLEMS

While event thinking and the idiot give us some conceptual tools with which to make sense of how encountering inarticulacy might help us to make new problem, they offer little in terms of practical guidance in how to develop situated accounts of these practices. Such reflective accounts are a core element of design-research practice [5]. However rather than simply giving a cursory nod towards reflective practice [6], we looked to Critical Incident Technique (CIT) as used in the field of Education as means to structure *event-oriented* reflections. CIT has its origin in studying pilot errors in the second world war [24], but has been applied across multiple areas of professional practice as a means to reflect upon and improve practice, to prevent such incidents from reccurring [11]. However, in the field of education, Tripp considers critical incidents not as something that just 'happen', but instead are made through a process of noticing, reflecting, and analysing [4,57]. For Tripp, there is often as much to be gained from making a critical incident out of a routine occurrence as there is with dramatic disturbances in teaching practices. Mundane incidents can be made critical by making explicit their connections to, and significance within, a broader practice of learning [57]. This approach to uncovering what mundane experiences have to say about

broader systems has clear parallels with the tactics adopted by many of the critical practices discussed above.

In some senses, CIT has many of the same features as the kind of reflective accounts that form the backbone of practice-based methodologies like RTD [5,15,53]. However, they also differ from most reflective accounts found in RTD in their explicit focus on singular events rather than narrative accounts of projects from start to end. In light of this, we present two first-person accounts of encounters with inarticulacy within our practices and critically reflect on their wider significance in order to translate these experiences into new problems. Rather than presenting a description of the projects from initial conception to eventual resolution, we instead focus our accounts on the moments at which we had cause to slow and consider *what we are busy doing* [43]. By focusing on these moments of inarticulacy, we expose the ways in which design research as a form of critical inquiry is not a linear process of articulation. Critical design is a form of inquiry that seeks to change how the world is articulated. It is intended to be unsettling, and its unsettling effect works not just on its audiences but on its practitioners too. Viewed from this perspective, critical incidents are not design-research going wrong. Critical incidents are what critical design research is aiming to produce.

GATEHOUSE'S REFLECTION: CAPTIVE PORTALS

I wanted to make visible the technological, social and cultural life of wifi so that it might be reimagined. I wanted to reach into the black box and make its working clear for all to see. I decided to create a public wifi network which would trade data in exchange for internet access. It would be a *captive portal*, the technical name for interfaces that pop up on connecting to a wifi network and ask you to give over personal data and/or agree to terms and conditions before granting internet access. These interactions are black boxed, in the sense that while captive portals are designed to be 'user friendly', the exact mechanism by which the connections are made or denied is unclear. The act of connecting to a public wifi network is also a common-enough experience of moving through public spaces, one that is only noticeable if it fails to work. So, public wifi is also black boxed in the sense of being unremarkable, even to the degree that while most people with a wifi-enabled device will be familiar with interacting with captive portals, few know what to call them. I wanted to unsettle wifi in order to reopen these black boxes, to consider how wifi 'worked' technically, and socially and culturally too. To do this, I wanted to redesign the experience of connecting to a wifi network to produce an uncanny experience of a mundane technology.

I began by reflecting upon my own experiences of using public wifi and observed the pragmatic way I would disclose personal information in exchange for wifi access. I didn't do this in complete ignorance of the possible loss of privacy, nor did I embrace an attitude of radical transparency that was indifferent to how my data was gathered and used. I was careful which networks I joined, but also aware of my reliance on my connections to networks in order to travel, socialise, and work. Sometimes I would abandon my worries about privacy because I really needed to send an email, or because I was sufficiently bored in an airport waiting lounge. I wanted to make an interface that reflected my experience and perhaps prompted others to engage in similar reflections about the deals that we strike to use network technology.

However, my efforts to coax a wifi router into doing what I want only lead to frustration. I am not a developer or a computer scientist, but I have always managed to make things work eventually. I have a certain pride in my ability to figure this stuff out. I start by tracking down open-source code, tutorials, blog posts, stack overflow threads that might help me make my captive portal. The tutorials I find fall into three categories: hobbyist home networks that produce 'home brew' versions of conventional wifi routers, 'penetration testing' applications in which white-hat hackers use wifi networks to test and probe system security, or open-source projects that attempt to realise something closer to dream of the truly decentralised network architecture. But what I want to do sits somewhere else. Not in hobbyist tinkering, not in the paranoid worldview of hackers and not the radical openness of the techno utopianism. Instead, I want to articulate the pragmatic negotiations with the uneven power structures of networked technologies that reflect my experience of using public wifi networks.

What I want to make is simple enough to describe. Users should be able to connect to my wifi network, interact with the locally-hosted website. Then based on those interactions, users will be granted timed access to the internet. And while I know, in theory, how this can be done, I somehow cannot make the parts work together. I spend days staring into the blackness of the command line, entering commands I only half understand in the hope of making the parts join up. I ask around, and I am told by those more technically proficient than myself that I need to start again. I need an 'enterprise' level set up, rather than my hacked-together code running on a raspberry pi. By this point, I can't face the prospect of configuring and cajoling an even-more-complex system into doing what I want. I have used up all of the mental and emotional resources I had in getting this far. I am beginning to doubt the project, doubt wifi networks: I begin to notice all the ways in which so called 'enterprise' wifi networks were unreliable: the bad security, the text-only redirects, the pop-up login which don't work. I begin to suspect that this wasn't just my failure, but that wifi networking was less smoothly engineered, less articulate, than I had previously noticed.

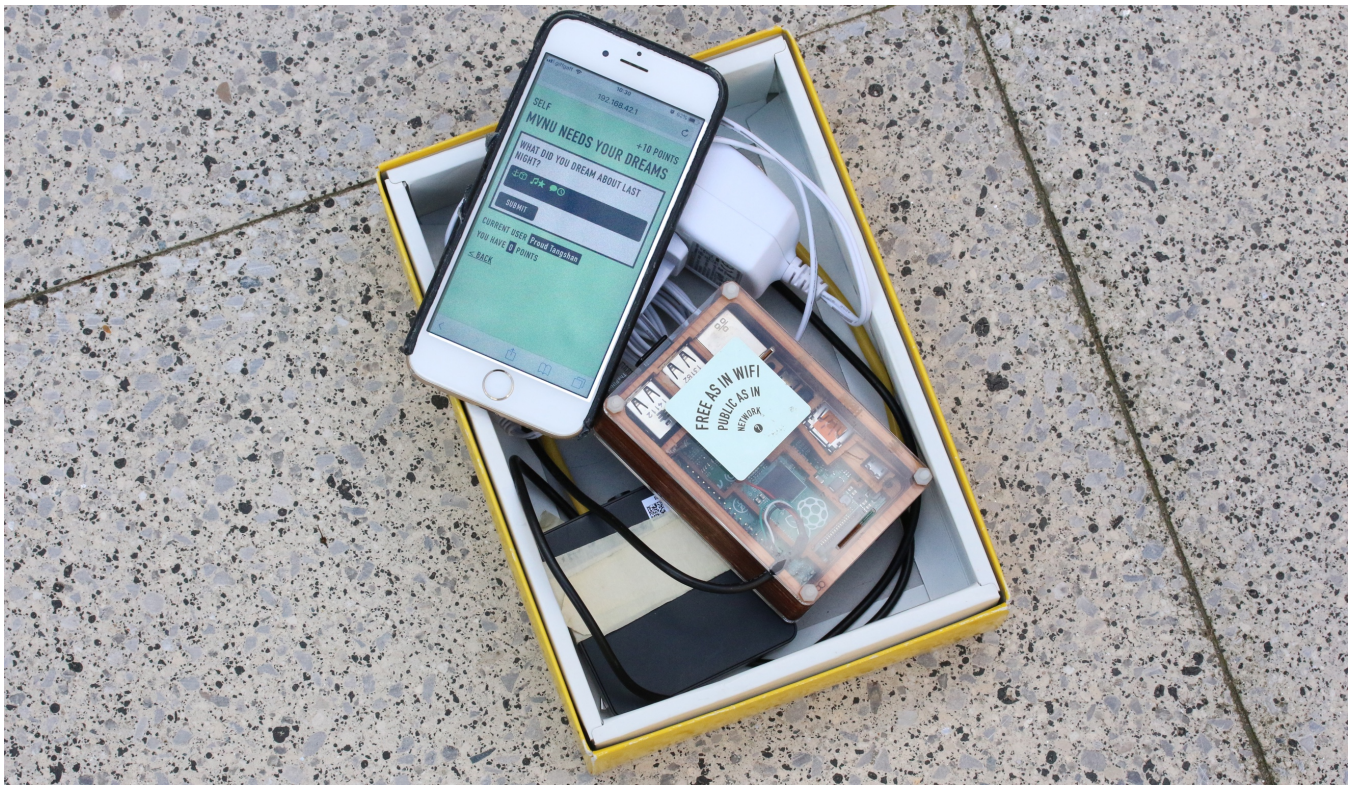

Figure 1. The Captive Portal and 'The Dream' task © Cally Gatehouse

From Data to Dada

However, this inability to make the network connectivity of the captive portal function as I wished was only one way that I encountered inarticulacy in making this device. The visual and interaction design of the screen-based user interface didn't really make sense. While neither the rationale for the design, nor the individual elements, were not obviously faulty, as a whole, it didn't present a coherent statement or experience. It was intended to be a series of interactions that would generate data, but at the same time its aim was to critically reflect on data as currency. However, the design seemed to get completely warped by a perverse and contradictory stance on data collection. This ambivalence was further complicated by my position as a researcher. On one hand, I needed data as the raw material of research, but this need was complicated by the view afforded to me by my engagement with wifi networking.

Working with the captive portal had the potential to gather a dizzying amount of data. If I had wanted, I could have extracted all kinds of personal identifying data. It is possible, for instance, to use a wifi router to get a list of every network that a person has ever connected to. From there, you could map the locations of these networks and then infer where this person lived, their profession, where they had travelled, where they drank coffee. While collecting this data would have been difficult to justify within the norms of research ethics procedures, the potential to do so was vertiginous, seductive even. Network technology was like a mirror. When I looked into it, I saw my own hunger as a researcher for data and participation reflected back at me. To be a researcher in the time of big data is a troubling thing: collecting data on people and things which are already so counted, measured and tracked is a challenge to what it is possible and ethical to know.

Trying to parse these contradictions into a usable design became challenging. The user interface for the captive portal was a website that, while built using the same building blocks as most responsive web interfaces, was slightly off kilter. On connecting to the network, people were meant to be redirected to a page where they would be greeted by two dialogue boxes explaining that their data would be collected and asking for consent (the second of which was mandated by a research ethics process). After consenting to this, people could select from a range of tasks that would 'earn' them time connected to the internet. I dreamt up dozens of these tasks, some more feasible than others: to add their name to list of fictional names, to choose to catch or drop an imaginary ball, to move 15 meters away from other wifi users, to take a picture of something powerful, to trigger an anonymous Twitter account to tweet, to make a flag, to judge computer-generated poetry, to rate the value of all other tasks. For the brief period of time that the captive portal worked at an exhibition, I watched as people were mostly baffled by this Dadaist approach to data collection. Even the

tasks that weren't completely baffling to users seemed to be designed to baffle me. The task that engaged people best was called 'the dream'. It asked people to enter a description of what they dreamt about last night into a text box. However, when they began to type, it displayed symbols rather than letters, opening up multiple ways of encoding the text.

This was directly inspired by the question 'How can you extract user requirements from dreams?' posed in Gaver *et al.*'s paper 'Cultural Probes and the Value of Uncertainty' [32:55]. Cultural Probes draw influence from surrealist games that 'subverted academic modes of enquiry, and undermined the complacent certainties of the reasonable and respectable' (Gooding, quoted in [32:54]). In this spirit, any data produced from interacting with 'the dream' task would resist conventional forms of analysis, not just because of its unusual form (should it be read textually or visually? Or both?), but because a dream itself is a product of the black box of the unconscious mind.

To stand on the edge of big data is to be tempted by an epistemic regime in which it is possible to do away with black boxes entirely. Big data tempts us to believe that there are no limits to what it is possible to know, that with enough server farms, enough sensors, we can know everything. More than that, it is an imperative to know everything: 'If the big-data fundamentalists argue that more data is inherently better, closer to the truth, then there is no point in their theology at which enough is enough. This is the radical project of big data. It is epistemology taken to its limit.' [13] (Crawford, 2014, online). Zuboff has written about how big data platforms are informed by a perspective in behaviourist psychology that 'reduces human experience to measurable observable behaviour while remaining steadfastly indifferent to the meaning of that experience' [61:377]. Zuboff argues that big data enables a regime she names 'Surveillance Capitalism'. A central tenant of Surveillance Capitalism is a belief that by collecting enough data about past behaviour, it becomes possible to know and predict all future behaviour. The 'black box of the self' that is so central to the psychoanalytic and surrealist discourses that inform cultural probes, becomes irrelevant, as only outwards behaviour is the only thing that counts and is counted.

Viewed through the lens of big data, the contents of a dream, ambiguously and idiosyncratically encoded in words and symbols, is illegible. Even if more plainly written, a dream cannot be articulated as big data because its meaning is derived from the 'black box' of human experience that surveillance capitalism discards in favour of outward behaviour. The insertion of the psychoanalytic discourse into networked data collection strikes at the heart of the anxieties of big data: that black boxes have not been banished but remain in a form that will always escape the gaze of surveillance capitalism.

Inside A Black Box

I had hoped to produce an articulation that made it possible to reflect on public wifi as a mundane technology. I hoped that this would allow myself and others to reflect on the how this technology articulates practices, values and beliefs. I hoped that, by doing this, it would be possible to collectively imagine how network technology could be reimagined more generally. I was trying to articulate wifi in way which could make it perceivable as an issue for such collective consideration. In case of public wifi, it is a 'non-issue' not because it was deliberately hidden from view or an emergent problem, but because its ubiquity made it unremarkable.

Facing growing disenchantment with the project, I scale back the functionality. I confine it to the local network only (I start to notice that most wifi art projects do this). And it works in a limited way, until it doesn't again. Something changes in the broader ecosystem of the network. It's hard to pin down what exactly caused this breakdown, but I suspect an update to mobile operating systems has changed the game. At this point, I am feeling similarly broken. I have lost faith in my ability to make things work, to join and articulate parts of the networked systems. The thought of another day fruitlessly trying to manipulate the device into doing and saying what I want makes me feel claustrophobic, trapped.

Implicit to this approach to research was an assumption that reflection is linked to agency. That through the knowledge of situation gained through reflection, I (and by extension my audience) would be granted some degree of agency to change these practices. However, I was quickly hit by the limit of my individual capacity to assemble this technology differently. Within the limited technical, emotional and material resources available to me, I struggled to find an articulation that reflected my experiences. While other positions were technically possible, they resisted my attempts to articulate them within the means I had to build and maintain them. I also found that the agency to articulate wifi differently did not reside in my hands alone. Instead it was distributed across multiple overlapping systems: a change to the wider ecosystem such as an operating system update can render my articulation non-functioning overnight. I do not know why exactly why the captive portal finally stopped working, and I have come to live with not knowing why. However, in the wake of my inability to articulate my reflections as a networked technology, what am I left with? My story begins with pride in my ability to investigate and manipulate the network but ends with me feeling in the dark. I began by wanting to open a black box of technology but ended up feeling like I was inside one.

CHATTING'S REFLECTION: CHANGING THE WALLPAPER

The subject of my inquiry is *domestic networked stuff*; *stuff* in Brand's conception of the *Shearing Layers* of a building [8], "*all the things that twitch around daily to monthly"*. To these ends, I was drawn to the Amazon Kindle, the electronic book reader with the e-ink display from the online retail giant. The Kindle fits nicely my notion of *domestic networked stuff:* small battery-powered and wirelessly connected to the Internet, with a mobility to cross from inside to outside of the home. The infrequently changing non-

emissive e-ink display is at one with the environment of the object and the room. It does not create its own artificially lit reality – the object seems materially changed by the display. When on standby, the Kindle becomes an advertisement. To me this seems a greater intrusion than the ephemeral flicker of a TV ad; an object I own has become changed in ways I do not control and runs counter to my sense of home, to William Morris' maxim to, "*Have nothing in your houses that you do not know to be useful, or believe to be beautiful*". So, it was my desire to digitally replace the Kindle adverts with wallpapers from Morris' cornflower series. My design practice is grounded in building working hardware and software prototypes, so I assumed this would be a relatively trivial and quick demonstration of my inquiry's values. Instead, as it turned out, over several ad-hoc months of effort it slowly began to generate understandings of the network beyond the Kindle and suggested alternative possibilities for the Internet of Things (IoT).

So, with a degree of chutzpah I made my initial Google searches. These showed that from the introduction of the Kindle *with Special Offers* in 2011, the first model with WiFi at a discounted price for carrying adverts, people had devised ways to block or replace these adverts. Two broad routes were suggested; to modify the Kindle itself or to modify the network of linked resources in which it exists. To modify the Kindle would likely require that the device become *rooted* (a *hack* that grants *root* administrative full-access to the filesystem) and possibly requiring the case to be opened and some hardware modification made. The modification of the network would require some *hacking* of the local WiFi network, making changes to the local router to trick the Kindle into taking William Morris wallpapers rather than Amazon advertisements. Both routes represent a *hack* of the collective; in Mouffe's terms, "*disarticulating the existing order*" [45]. It is the *network* that defines my interest in this *stuff* and so I looked at ways to hack the local router.

Through my online searches I discovered two pieces of software that were quickly written in 2011 and shared, intended to replace the advertisements delivered to the Kindle with any image saved in the common gif format — these being *pwnazon* by Michael Shepard [54] and *k4freeserver* by Piero Toffanin [56]. They were distributed as source code, in the well-known PHP and Ruby languages respectively; today both are available on the popular Github platform. The scripts are short and with some programming knowledge one can gain an understanding of their operation through simple inspection.

Both *pwnazon* and *k4freeserver* operate in identical ways; the Kindle proactively makes *HTTP* (*Hypertext Transfer Protocol*) web requests for image content from the identifiable server *adpublisher.s3.amazonaws.com* which returns an image in the gif format. This transaction is intercepted, and an alternative image delivered. The *HTTP* web request is the same mechanism by which an image is delivered to a web browser and is an extremely common way by which data of all kinds is transferred by connected things of all kinds. It is these messages that join the network together, in DiSalvo's terms, that articulate the collective.

Even the domain name *amazonaws.com* — the AWS (Amazon Web Services) — hints at the enormity of the Amazon cloud-based collective on which the Kindle invisibly hangs and contributes its data.

The intercept of advertisement images relies on a key infrastructure of the Internet, that of *DNS (Domain Name Servers)*: the means by which a computer's *domain name* is translated into its associated *IP (Internet Protocol) address* – the Internet's underlying addressing scheme. This is how for instance *www.amazon.com* is resolved to *13.32.69.252*. A DNS request will be made at the start of any communication; initially with the local router and then, if unknown there, with well-known DNS machines at the heart of the Internet. *pwnazon* and *k4freeserver* both rely on changing the local DNS server on the home router, such that when the Kindle makes a request for *adpublisher.s3.amazonaws.com* it is returned with the IP address of a local machine running a spoof website serving alternative imagery, rather than the address of Amazon's remote servers. In a similar approach, specific domains can be effectively blocked by rewriting the local DNS record for a domain as *unknown*. This is how network level ad-blocking software such as Pi-hole works [51]. I had a good understanding of this this mechanism as I began this exploration.

My home router's DNS log showed a long list of the servers my Kindle was interacting with. The entries included those for time, software updates and messaging services – as well as a regionalised advert service for Europe. A little more of the infrastructure was revealed to me. I could block all the adverts from *adpublisher-eu.s3.amazonaws.com* by simply rewriting the router's DNS record. However, when I tried to use *pwnazon* and *k4freeserver* to replace the imagery I was frustrated, they no longer worked. By reading articles on Stack Overflow and other forums, it became clear that in around October 2013 Amazon had changed the firmware on the Kindle, in an Over-the-Air software update, so that rather than using *HTTP* it now used *HTTPS* (Hypertext Transfer Protocol Secure). The Kindle's web requests were now secure. The consequence of this, that I did not previously understand, is that the device verifies the identity of the server it is talking to and then encrypts its messages such that only that recipient can read the data. As such the Kindle rejects the local machine's attempt to impersonate the Amazon server. A different strategy was required, which would need me to develop some deeper understandings of HTTPS.

Figure 2. A Kindle (temporarily) hacked to display William Morris wallpaper in place of adverts. © Cally Gatehouse

With an HTTP exchange the source destination and data payload of every message sent by any device on the network is inspectable by all on the local network or at any point between the server and client (using tools such as *Wireshark*). This includes the full URL of the resource, any parameters – including usernames and passwords and the contents of the reply – for instance HTML or image data. Everything in the HTTP exchange is readable and could be modified or stored in transit, without the knowledge of either server or client. Further, the client is offered no guarantees of the authenticity of the server's identity – all of which was exploited by *pwnazon* and *k4freeserver*.

While I understood that HTTPS was *secure*, it had been a *black box* to me. HTTPS implements TLS (Transport Layer Security) a cryptographic protocol that authenticates the identification of the remote server and then encrypts all the traffic between the two. Requesting a resource from a server then becomes a multi-stage process, as these details are negotiated and certificates exchanged and verified. TLS is commonly referred to as SSL (Secure Sockets Layer), the protocol it succeeded. As I discovered, this means that in inspecting the HTTPS traffic between the Kindle and Amazon, only the destination hostname and destination IP address is visible. Without knowledge of the session-key used for encryption only simple statistics like payload length and message rhythms can be discerned from the exchange [1]. Modification of payloads becomes impossible, and as a result I cannot change the wallpaper.

With a so-called *man-in-the-middle* (MITM) attack I could, perhaps, intercept and decode the Kindle's HTTPS traffic, but to do that I needed to get the Kindle to accept a *Certificate Authority* certificate. Such certificates are issued by a set of well-known trusted Certificate Authority (CA) servers. However, with access to the device's filesystem certificates can also be locally installed and be written to verify the false identity of the MITM machine. This required a change to the device and not just the network in which it finds itself. A bewildering set of forum posts documented how this might be achieved; each dependent on a slightly different model of the device and version of the operating system. Nothing worked for me.

Finally, I changed tack – I broke open the case, cracked the screen and soldered a connector on the PCB – I had terminal access to the Linux kernel that lurks beneath! Once I had this view, a curious thing became apparent: the downloaded ad images were stored in a hidden directory accessible to my laptop when the Kindle was connected as a USB drive. I plugged my Kindle in, navigated the files system, replaced all the image files; lo and behold William Morris' cornflowers filled the screen. But the blooming was brief, 20 minutes later the Kindle had downloaded new adverts in their place. The hegemony was restored.

On reflection then, what had my encounters with the Kindle revealed? Firstly, it situated my device in a tangle of online infrastructure and authority. Then through my invention, I began to witness how this network resisted and enabled my efforts. Through my inquiry then I was developing a critical position of secure protocols as applied to our *domestic networked stuff*. While it is clearly desirable that messages cross the Internet securely, the growing adoption of HTTPS in closed IoT devices (like the Kindle) means that the nature of the data exchanged or leaked from within the home to

external servers is becoming increasingly difficult to know or monitor. The intentions of the manufactures having acquired this data are equally opaque. The dominant narrative in the technology press is of people *hacking into* your home, yet this assumes that we trust the agents and their networks already inside it; should we then find ways of *hacking out*? Further, while the hardware is static, its connectivity renders the object slippery and impossible to reliably articulate. The device's behavior becomes the consequence of multiple actors in the network and is subject to change. That one might enact a single hack, for once and for all, now seems naïve – it's necessarily a struggle – a toing and froing.

DISCUSSION: THE TROUBLE IS THE POINT

These stories of doing design research do not conform to the idea of reflective practice as a process of verbally articulating [52]. Instead, both stories begin with us being able to describe our aims and objectives for what we want to make. They also complicate DiSalvo's account of designerly critical inquiry that translates a messy situation into a more articulate form, from which new sense can be made. As our material exploration of these problems progressed, the objects we are making became less coherent, their structure and significance became more obscure. And while DiSalvo acknowledges that articulating such structures might also require disarticulating certain joins, inarticulacy is something different. The inarticulacy we encountered was a join that resisted being made or was made in ways that make the collective go into dysfunctional spasm.

These spasms seem to result from our tactic of using the materiality of the network itself as the basis of our inquiry. We found ourselves unable to arrange the technology to reflect practices, values and beliefs, other than those embedded in, and enabled by, the existing configuration of network technology. We were constrained by existing agencies and the power imbalances inherent to them. Why then proceed with material explorations like these if they caused us so much trouble? Why not pursue other forms of design research that address these problems in other, perhaps more malleable forms? I (Gatehouse) could have made a probe in any number of forms that didn't involve directly configuring WiFi networks (as has been done successfully in ref [47]). Chatting could have photoshopped a mock up of the William Morris wallpaper on the Kindle screen.

We could have pursued any number of alternative modes or materials for addressing our concerns. Indeed, our intention with this paper is not to argue that material exploration is better or worse than others forms of designerly inquiry (indeed, we have engaged with these in other contexts [22,28]). Rather, our point is that while alternative methods might have saved us the specific kind of trouble we encountered in our material explorations with network technology, we would have still needed to go looking for trouble elsewhere. Because, for critical design, finding and staying with the trouble is the point.

Knowing With and Against the Grain

What then is the particular nature of the trouble we encountered as a result of our choice to engage in these kinds of material explorations? These stories are not simply a case of technical incompetence; the point is not that we are ignorant or don't understand, nor that we don't have the right tools or resources needed to make the things we want. We know that given enough resources, it is possible build a functioning captive portal and it is possible to make an ad-replacer for a Kindle. However, RTD does not ask the question of what is possible in the abstract. Instead, when we engage in knowing through making, we are asking 'what can *we* do?' Practice is always inescapably situated, and so is the knowledge it produces [33]. And perhaps this is why it is important to also ask 'how hard is it do this?' From there, we can begin to wonder why is it so much easier to build an ad blocker rather than an ad replacer? Why is it easier to build a captive portal that takes people's data without asking than one that tries to negotiate this as a mutual exchange?

Working in these ways did not just reveal how power is distributed unevenly by network technology in the generalised sense that we had at the start of the projects. These encounters brought us into contact with the specific ways that things like HTTPS and DNS work together and against each other to distribute power across the network. We found like any material, the elements that make up network technology are finitely mutable. Just as paper has a grain that makes it easier to tear along one orientation than the other, the network has a grain that means an ad blocker is easier to build than an ad replacer. These material properties define the design space that both allows and constrains our ability to articulate our concerns and values. Material explorations such as ours are a means to encounter materials that allow us to begin to feel out the possibilities offered by it, but also we become sensitive to what these materials resist articulating.

The result of this serious play in our case was not a set of solutions to the problems we were concerned with, nor answers to our questions. Instead we produced new ambivalences and ambiguities. So, while encountering inarticulacy was troubling, frustrating even, it was ultimately productive in terms of helping us to identify new problems in the manner outlined by Fraser. Concerns with IoT are normally centered around the lack of security [23]. However, Chatting's experience revealed a much more ambiguous perspective on encrypted internet traffic. It sensitized him to the way that encryption shifts the balance of power in the network. HTTPS is a social and technical settlement that allows our data to be more secure at the cost of a network where power is less evenly distributed. Unencrypted data is vulnerable to attack across the entire network because the power to read, edit or share it is distributed evenly. Encrypting this data makes it more secure but at the cost of centralizing power into the hand of large technology companies like Amazon.

Captive portals themselves exploit the fact that DNS is a more distributed element of the system to redirect users to a login page in exactly the same way that the Kindle hacks do. And as my (Gatehouse) experience showed, captive portals are also vulnerable to the same kind of system updates that rendered the Kindle hack non-functioning. Through my material exploration I developed an increased sensitivity to the ways in which WiFi networks are likely to break down or fail. I also gained a better sense of the nature of my agency and, as a result, I am perhaps a little humbler in my attitude to working with these technologies. Together these things sensitised me to the surprising precarity of mundane technology such as WiFi, and the difficulties of effecting change in the 'agential soup' [10:5] of network technology.

Sense to Sensibility

What we gained from these encounters was not just new insights but new ways of looking at networked technologies. These encounters have reoriented our research practices, leading to new lines of inquiry and new concerns. However, for some, this paper may raise concerns that we are providing means by which bad design can excused, or even valorised. However, there is a sleight of hand going on here: we have been able to do this by swapping the need for design outcome for a research outcome. We have been able to 'get away with' presenting inarticulate design outcomes, but we did this by instead producing an articulate research outcome.

Here we have considered how we responded to encountering inarticulacy in the context of critical practice. However, inarticulacy is always with us when we design. What is different about critical design as a form of research is that allows us to bear witness to inarticulacy in a particular way. In this paper, we have begun to translate these newly formulated problems in a written form. However, these encounters have also reshaped the sensibilities [60] that inform our design practices. They caused me to find new conceptual figures that represent different responses to network technology, while Chatting has begun to develop devices and other materials that demonstrate the design space opened up by network technologies.

However, Michael warns us that we cannot escape to some degree instrumentalising our encounters with inarticulacy. There is always a risk that as 'soon as we think we have "deployed" the idiot, slowed our thinking, and invented novel problems, we have also tamed it, and the process of querying our assumptions has become compromised' [43:9]. In other words, how do we avoid allowing our newly identified problems to themselves become settled? Can we retain some of the unsettling qualities of the original encounter in how we articulate what we have witnessed?

We would like to suggest that a potential answer to these questions lies in the long-standing engagement with ambiguity in design-research. Inarticulacy is not an unfamiliar component of design practice. Art and design have a long tradition of using ambiguity as a way of making uncertainties visible [21]. Ambiguity as more deliberate form of inarticulacy has been recognised as lending itself to a richness of experience within design-research [60]. Ambiguity is also valued in design because it leaves space for dialogue and unexpected responses [31]. Having brought us into contact with inarticulacy, we found that design research had prepared us to respond to it. While encountering inarticulacy slowed us down and threw us off our intended path, it did not halt our inquiry entirely. Design research offered a means through which we could begin to respond to this inarticulacy through identifying new ambiguities and ambivalences. Through embracing modes of articulation that retain some of the ambiguous or unresolved elements, we can translate inarticulate presences into forms that allow them 'speak' in ways that invite further problem making.

Embracing ambiguity in this way can also help us to resist the epistemic regime that is implicit in so much network technology. Zuboff has written about how the viewpoint afforded by big data and Surveillance Capitalism is marked by a tendency towards 'observation without witness', that this leads to knowing as a kind of 'radical indifference' [61:377]. In contrast, the design research methodology exemplified by Cultural Probes, 'recognizes and embraces the notion that knowledge has limits […] That values uncertainty, play, exploration, and subjective interpretation as ways of dealing with those limits' [32:53]. This is not done as a nihilistic disavowal of knowing entirely, but as a commitment to a playful, empathetic, provisional form of knowing that acknowledges, or even values, not knowing. Such a research method recognizes that knowing involves both revelation and occlusion, but does so with emphasis on increasing our capacity to be present and responsive to the people and things we encounter.

CONCLUSION

Networked technology is both a material articulation and 'the imagined collective that emerges as a result of the intersection of people, technology, and practice' [7]. Just as the printed word once reshaped how we imagined nation states [3], the materiality of the network gives us a model for imagining not just itself, but also a model for imagining the world. Fraser has pointed to the way that what exists 'will never fail to fulfil its obligation to produce itself and its own values, even though these values are not necessarily to be valued' [26:69]. We found the existing values of the network reasserted themselves in the face of our attempts to articulate different ones. Crucially, this reproduction of existing values extends beyond the materiality of network technology and into the network as a way of imagining the world. As Bridle puts it, 'we cannot unthink the network; we can only think through and within it' [10:12]. Even our wildest fictions are shaped by the network as it exists, often in ways we might be only barely be able to perceive. Design research as a form of critical inquiry brought us face-to-face with the ways in which the network is inarticulate through material and discursive engagement with it.

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