You are not here

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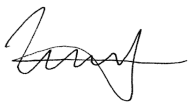

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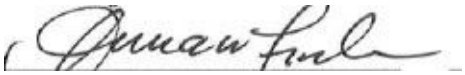

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ABSTRACT

“You are not here” provides an opportunity to engage materially and experientially with the geolocation systems behind virtual map interfaces through site-specific installations and interventions. By bringing awareness to the obscure activities that happen behind digital interface screens, these creative works invite critical reflection on post-digital sensibilities which are increasingly dematerialized.

Keywords: wifi, gps, google maps, material, systems aesthetic, net art, installation, intervention, interface, cloud computing

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Table of Contents

Introduction

I started this thesis 30 years ago. As a child, I would spend hours on end dismantling and prying open lamps and rotary phones to gaze into their inner workings. The ticking mechanisms and glowing lights energized my curiosity to learn more about the electronics around me. Looking at the thin copper etchings on circuit boards, I would imagine electrons streaming through devices like water flowing through pipes. It was through these experiences that I was drawn to and why I subsequently studied electrical engineering. Marrying my curiosity with what became my craft helped guide my artistic exploration of digital technology; not just as a tool but as a medium for aesthetic exploration.

Unfortunately, the devices of today do not inspire the same curiosity. Unlike the electronics of my childhood that invited tinkering, today's digital technologies seem to evade and discourage curious examination. Contemporary digital technologies are specifically designed to prevent consumers from 'peeking under the hood.'[1] Concealed behind proprietary and inaccessible technologies, most modern devices do not allow for straightforward technical exploration. In our current post-digital condition, the digital has infiltrated every aspect of culture and society.[2] Smart devices increasingly rely on wireless technologies for mobility and real-time interaction; prying them open does not reveal as much as tinkering once allowed.

Smartphones, in particular, are continuously tethered to network infrastructures that enable users to seamlessly interact with their environment. Even when their screens are turned off,

[1] "Right to Repair - IFixit," accessed May 21, 2020, https://www.ifixit.com/Right-to-Repair/Intro.
[2] Florian Cramer, "What Is 'Post-Digital'?," in *Postdigital Aesthetics: Art, Computation and Design*, ed. David M. Berry and Michael Dieter (London: Palgrave Macmillan UK, 2015), 12–26, https://doi.org/10.1057/9781137437204_2.

smartphones are still “online” and perpetually transmitting and receiving data.[3] This persistent connectivity ensures that Yelp reviews, text messages, navigation directions, etc., are instantaneously made available on the screen with a simple click or swipe. While one sees its glowing screen and feels its beveled edges, smartphones are just the endpoints in a highly complex web of technical infrastructure. The average smartphone user is part of a “planetary-scale computational system”[4] that remains incomprehensible in post-digital societies.

The seamless experience afforded by smartphones is the result of the emergence of the cloud-computing paradigm.[5] While this may evoke notions of data droplets floating through the air, cloud computing functionally serves to define the abstract design for information systems architecture. In cloud computing, all the information storage and processing is done - from a distance and out of sight - away from the smartphone. By taking advantage of the robust communication infrastructures, designers and engineers offload the processing to remote servers. Algorithms on these remote servers process all data received from smartphones and transmit them back to the user. As such, the smartphone functions just as a screen to display, an interface to, the results of complex activities that occur at remote locations. Thus, the “smartness” of a smartphone is attributed to its ability to be in perpetual two-way communication with these remote data centers. While there are numerous technical advantages of cloud computing, such as the ability to update services without disruption, this ‘virtualization’ also limits the exposure between technical systems and the user. The cloud, by virtue of its technical design, has the ability to “hide the material cost of its infrastructure behind a facade of individual user freedom and flexibility.”[6] Thus, the seamless experiences that have become commonplace

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[3] Sherry Turkle, “Always-On/Always-On-You: The Tethered Self,” in *Handbook of Mobile Communication Studies*, ed. James E. Katz (The MIT Press, 2008), 121–38, https://doi.org/10.7551/mitpress/9780262113120.003.0010.
[4] Benjamin H. Bratton, *The Stack: On Software and Sovereignty*, Software Studies (Cambridge, Massachusetts: MIT Press, 2015).
[5] “Cloud Computing Paradigm - an Overview | ScienceDirect Topics,” accessed May 27, 2020, https://www.sciencedirect.com/topics/computer-science/cloud-computing-paradigm.
[6] Tung-Hui Hu, *A Prehistory of the Cloud* (The MIT Press, 2015).

in post-digital societies, necessitates that the average remains oblivious to the complex, yet material, realities behind their screens.

Cloud computing has also resulted in the proliferation of interfaces. Companies like Google, Apple, Microsoft, and Amazon (GAFAM) increasingly develop digital interfaces that enable users to take advantage of the power of cloud computing. For example, Google Maps, a virtual map interface, functions by gathering real-time GPS coordinates from smartphones, cross-referenced with spatial information stored on Google's servers, and relays back relevant information instantaneously. This is all smoothly rendered on the screen. This mechanism allows users to seamlessly interact with physical space through virtual map interfaces. While the average user possesses the acumen to exploit the features of Google Maps, cloud computing ensures that they need not worry about the mechanism behind the interface. All the messy technical details are removed from the user's purview. Thus, interfaces are an "epitome of abstraction"[7] that characterize cloud computing. In the process, interfaces do not provide opportunities to experience, see, and directly engage with the systems behind them. The use of the interface creates ignorance, compliance, and banality and perpetuates the experience of the dematerialization of technology in post-digital societies.

You are not here provides an opportunity to engage materially and experientially with the geolocation systems behind virtual map interfaces through site-specific installations and interventions. By bringing awareness to the obscured activities that happen behind digital interface screens, these creative works invite critical reflection on post-digital sensibilities which are increasingly dematerialized.

[7] Ibid.

To provide a material engagement with geolocation infrastructures in and around the Stamps Gallery, I approach WiFi & GPS in the same manner as early net artists who engaged with the materiality of the Internet. These creative practitioners built critical awareness of network infrastructures by directly manipulating and visualizing HTML code. Similarly in this thesis, I manipulate invisible electromagnetic WiFi & GPS signals. The effects of this manipulation are rendered on virtual map interfaces. Specifically, the seamless experience of virtual maps, in which they appear to perfectly align 'one to one' with physical space, is ruptured. Additionally, I also visualize physical traces of WiFi & GPS infrastructures in and around the Stamps Gallery. These methods i.e. of manipulation and visualization, allow visitors to directly observe the material infrastructures of geolocation systems that are otherwise designed to be hidden.

The focus of my thesis is to appreciate the operational qualities of geolocation systems that support the real-time mediation of virtual maps with the physical space of the Stamps Gallery. The creative works in this thesis provides ways to experientially engage with the aesthetics of geolocation systems that are otherwise very difficult to perceive. In order to do so, I relied on the strategies of Systems Aesthetics and its approach of using "software [technologies] as a metaphor for art."[8] Software is an intangible entity whose *perceptual* quality is *conceptual* in nature. One cannot *see* Software, one can only *observe* its effects. Opening up the computer does not reveal the software, it only shows the electronic circuitry. Even though software exists in the circuits, one cannot visually perceive it.

As a way to experience and grasp these concepts, Systems Aesthetics employs interactivity, real-time networks, didactic text, and minimalistic design. I use these same conceptual aesthetics in my creative works to enable observers to ponder the omnipresence of the interactions of WiFi & GPS systems within the Stamps Gallery rather than the physical objects in

[8] "Systems Art - Systems Aesthetics and the System as Medium," accessed May 6, 2020, http://systemsart.org/halsall_paper.html.

front of them. Most of the artworks in my thesis are meant to be experienced through the visitor's smartphone as they walk through the gallery. By integrating the installations with the visitors and their smartphones, I want their engagement with geolocation systems to linger long after leaving the gallery. Visitors may then continue to contemplate the complex mechanisms happening behind their screen and in their environment.

Interfaces are traditionally understood as both symbolic and technical devices such as graphical user interfaces (GUIs), keyboards, touchscreens, and microphones that enable humans to use and communicate with computers. But in the post-digital, these interfaces also function to mediate interactions between people, places, and things. As technology gets intertwined with all aspects of culture and society, interfaces shape all we see, sense, and understand about the world. Interfaces not only affect the way we interact with technology, but they also affect "the way cultural activities are perceived and performed."[9] Hence, the obscuring of systems by interfaces is not just a technical problem, but a social and cultural one as well. The ephemeral and dematerialized experience of the cloud "become[s] a potent metaphor for the way contemporary society organizes and understands itself."[10] The interface, in obscuring the understanding of systems, also obscures one's ability to realize the impacts of digital technologies on culture and society. Digital technologies take on mythological status, creating an empirical void in our understanding of these systems and these "myths [become] part of our reality."[11] I believe that in order to fully realize and appreciate the effects, a technical understanding of digital media is required. Friedrich Kittler once said that the "media determines our situation."[12] But when the media is obscured, how does one understand our current situation?

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[9] Christian Ulrik Andersen, "Manifesto for a Post-Digital Interface Criticism | The New Everyday," accessed May 21, 2020, http://mediacommons.org/tne/pieces/manifesto-post-digital-interface-criticism.
[10] Hu, *A Prehistory of the Cloud*.
[11] Christian Ulrik Andersen & Søren Pold, "Interface Mythologies – Xanadu Unraveled," *Interface Critique Journal* Vol 1 (2018), https://doi.org/10.11588/ic.2018.0.44738.
[12] Friedrich A. Kittler, *Gramophone, Film, Typewriter*, trans. Geoffrey Winthrop-Young and Michael Wutz, 1 edition (Stanford, Calif: Stanford University Press, 1999).

My research interests, and approach as an artist and engineer, are guided by the following questions:

What does it mean to engage with geolocation systems experientially? What does it mean to engage with geolocation systems materially? How do these modes of engagement challenge our assumptions about the post-digital condition?

In the following sections, I will contextualize my thesis by discussing historical precedents, relevant theoretical frameworks, and related work of creative practitioners. I will examine creative practices that engage with post-digital technologies. Specifically, I will highlight how their examination of digital technology is confined to the interface level. While these creative practitioners are able to articulate the effects of digital technologies on society and culture, they fall short in engaging with systems that are behind interfaces. Additionally, I will discuss how art and technology genres such as Systems Aesthetics and net art have influenced my practice. I will then describe the methods used in developing the artworks and how the artworks manifested for my thesis exhibition, detailing my aesthetic decisions. My thesis will culminate with concluding thoughts, insights, discoveries, and results that came through the making and researching of this work.

Context

Post-digital Condition & Interfaces

Innovations in digital technologies have always disrupted some aspects of culture and society. The post-digital can be viewed as the period after the so-called “digital revolution” is realized. While many debate when this event occurred, scholars agree that the post-digital describes the world in which digital technologies have become entangled with every aspect of culture and society.[13] In such a situation, digital technologies increasingly become the primary platform for interactions between people, places, and things. In post-digital societies, users of digital technology, now embedded with wireless capabilities, are no longer limited by the limitation of network cables, providing interactions with their digital ecosystems at any time and any place. To enhance the seamless experience of interaction between virtual and physical worlds, designers and engineers have developed the cloud computing paradigm. In cloud computing, the storage and processing of data is not confined to smart devices. Instead, sophisticated algorithms running on remote servers handle the complexity of real-time interaction afforded by smart devices. For example, when one uses a smartphone to navigate a city, remote Google servers gather GPS data from a user's smartphone. This data is processed and appropriate geolocation information such as turn by turn directions, nearby restaurants, local events, etc., are sent back to the user. Wireless technologies that tether smartphones perpetually to remote servers enable the smartphone to exploit the features of cloud computing to create an experience of immediacy.

[13] Cramer, “What Is ‘Post-Digital’?”

The offloading of work to remote servers, also called virtualization, creates a perceptual “gap between the real and the virtual.”[14] As data is received wirelessly, and transmitted from smartphones, the average user does not know where and how the data finds its way to far off places. So the cloud, in part due to the ability to provide real-time instantaneous interaction, also masks the “material cost of its infrastructure.”[15] This lack of exposure to the cloud’s material realities creates a fleeting experience of digital technologies in the post-digital. With a simple click, one can download the entire knowledgebase stored in the 1.5 million square feet of the Library of Congress. Spotify enables one to continuously stream audio files without the need to physically sift through albums. Google Street view allows us to walk through the streets of remote locations. We are able to Airdrop content across iPhones without making physical contact. As a result, the servers, buildings, technical equipment, electricity, and the labor needed to maintain the infrastructure are made inconsequential.

This dematerialized experience in the post-digital is further sustained through the use of digital interfaces. The majority of today's interfaces are designed, operated, and maintained by Google, Amazon, Facebook, Microsoft, and Apple (GAFAM). These interfaces allow their users to take advantage of the features of the cloud, i.e., interacting efficiently and seamlessly between virtual and physical worlds. Even though users can directly engage with the features of the interface, the material realities of the cloud are not exposed. Designers believe that the average user should not have to contend with the technological complexities of their devices. Perceiving the inner workings of computers, they contend “interrupts the smooth experience of interfaces.”[16] Thus, by design, the seamless experience necessitates that the user is unaware of

[14] Hu, *A Prehistory of the Cloud*.
[15] Ibid.
[16] Brenda Laurel, *The Art of Human-Computer Interface Design* (Addison Wesley, 1994).

the technical mechanism that happens behind the screen. In fact, this obscuring is a conscious design decision to render computers invisible.[17]

The functions of interfaces can also be understood through Kittler's theory of software. In his essay titled "There is no software," he claims that people do not write anymore with the shift from paper to computers. When typing in a word processor program, the words that appear on the screen are fundamentally different from the marks that appear on paper. Writing "does not exist anymore in perceivable time and space,"[18] but rather it exists in the voltage differentials at the level of miniature circuits that are inside of a computer. This hyperbolic, although factual statement is meant to highlight a key feature of digital media, i.e., abstraction. There are files, folders, and desktops in computers but these are just abstractions created to enable the efficient use of a computer. Humans have a conceptual understanding of a file and so software serves to translate the activity of complex electronic circuits to human processable language. Nevertheless, in this process, software also hides and conceals the underlying hardware architecture. Thus, Kittler points to the shortcomings of using software to comprehend the complexities of hardware. Interfaces, much like software, translates the complex functioning of systems for their users. While most people possess the acumen to use Google Maps to navigate cities, they are oblivious to the technical mechanisms behind the interface. Google Maps abstracts the navigation algorithms, real-time communication networks, routing protocols, etc., so that users do not have to contend with its technical complexity. Thus, similar to limitations with software, operating solely at the interface level falls short in allowing for deeper understanding and "we cannot appreciate the ways in which it shapes our experience."[19] As

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[17] Donald A. Norman, *The Invisible Computer: Why Good Products Can Fail, the Personal Computer Is So Complex, and Information Appliances Are the Solution*, Reprint edition (Cambridge, Mass. u.a. MIT: The MIT Press, 1999).
[18] Kittler, Friedrich, "There Is No Software," in *Literature, Media, Information Systems*, ed. John Johnston (New York, NY, Routledge, 1997), 147-155.
[19] Jay David Bolter and Diane Gromala, *Windows and Mirrors: Interaction Design, Digital Art, and the Myth of Transparency* (Cambridge, Mass: The MIT Press, 2003).

such, the mechanics of the influence of digital technologies on society and culture remain fleeting.

As digital technologies get intertwined with all aspects of our lives, the definition of interfaces should be expanded from their traditional understanding. Beyond functioning as graphical user interface (GUIs), buttons, touch screens, microphones, etc. that mediate the interactions between humans and computers, interfaces become the arbiter of "culture and technological materiality (data, algorithms, and networks)."[20] Interfaces not only enable users to access the plethora of digital services provided by GAFAM, but they also become the default way that consumers interact with the world. As society has become dependent on GAFAM technologies, these interfaces have the ability to shape and influence culture and society in profound ways.

The ability of interfaces to impact our world is well illustrated by the first-ever Google Maps war of 2010.[21] This example indicates the impact of GAFAM interfaces to affect social and cultural activities as well as global geopolitics. In 2010, Nicaragua invaded their neighbor Costa Rica 2.7 km past the border, claiming that land as their own. This particular area had been a disputed territory and was reconciled in a controversial treaty in 1858 as belonging to Costa Rica. Google Maps had incorrectly shown the territory belonging to Nicaragua. This error was used as a justification for Nicaragua to invade their neighbor. Once Google was made aware of the incorrect mapping of this area, they corrected the border on Google Maps to reflect the agreement of the 1858 treaty. This demonstrates how Google Maps as an interface, beyond just being a navigation tool, functions as an arbiter of international borders. But more importantly, this example indicates the power of interfaces and how they can be used even as justification for war.

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[20] Andersen, "Manifesto for a Post-Digital Interface Criticism | The New Everyday."
[21] Mark Brown, "Nicaraguan Invasion? Blame Google Maps," *Wired*, November 8, 2010, https://www.wired.com/2010/11/google-maps-error-blamed-for-nicaraguan-invasion/.

Could this invasion have been prevented if the parties involved had knowledge about Google Maps underlying technical architecture? While that might be hard to answer, this example nonetheless demonstrates how “we are seduced by the interface into neglecting the work behind it.”[22] The convenience afforded by interfaces obscures the networks, data, and algorithms that enable the seamless interaction with the world. “The interface[s] appear mythical, absolute and frozen”[23] because an empirical void exists in our understanding of them. As material realities behind interfaces are obscured, users are unable to comprehend the ways they can shape culture and society. The dematerialized experience perpetuated by the interface has “become a potent metaphor for the way contemporary society organizes and understands itself.”[24] Hence, for the average user in the post-digital, the experience of systems behind interfaces becomes increasingly fleeting despite the omnipresence of digital technologies.

Contemporary post-digital creative practices that contend with issues around digital technologies also tend to engage with the interface. For example, the artist Aram Bartholl highlights the layering of virtual maps on physical space through his public intervention titled Map (fig. 1). With the aim to provoke consideration of growing dependence on virtual maps, he creates life-size Google Map markers and places them in city centers. When “transferred to [the] physical space, the map marker questions the relation of the digital information space to everyday life public city space.”[25] By manifesting the markers in large physical form, Bartholl

[22] Andersen, Christian Ulrik and Søren Pold, “Interface Mythologies – Xanadu Unraveled.”
[23] Ibid.
[24] Hu, *A Prehistory of the Cloud*.
[25] “Map – Aram Bartholl,” accessed May 13, 2020, https://arambartholl.com/map/.

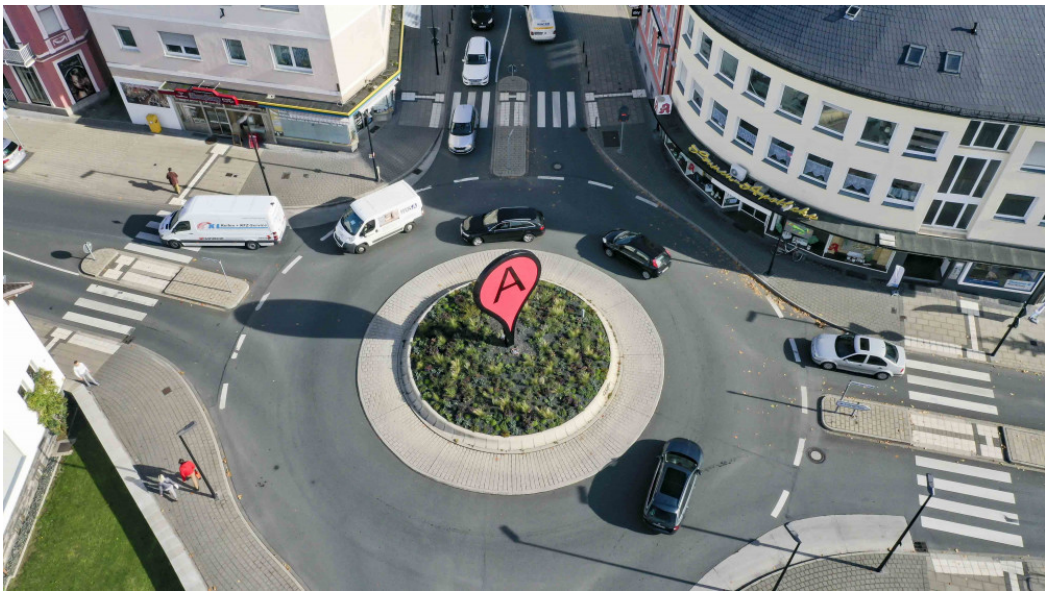

Fig 1. Photo documentation of *Map* by Aram Bartholl, Arnsberg Germany, 2019, https://arambartholl.com/map/

constantly reminds us of how virtual maps continuously mediate our experience of the city. While Bartholl speaks to how Google Maps mediates physical space, the architect Mark Shephard strives to disrupt the logic of virtual maps. In the project titled Serendipitor (fig. 2), Shephard created an alternative navigation app for the iPhone. In Google Maps, the algorithm is designed to optimize and provide the most efficient navigation route. In Shephard's app, users input their point of origin, destination, and select a level of "complexity"[26] to the journey. The app then suggests a route that takes visitors down unexpected streets to discover locations that

[26] Mark Shepard, *Sentient City Survival Kit*, accessed February 5, 2019, http://survival.sentientcity.net/index.html.

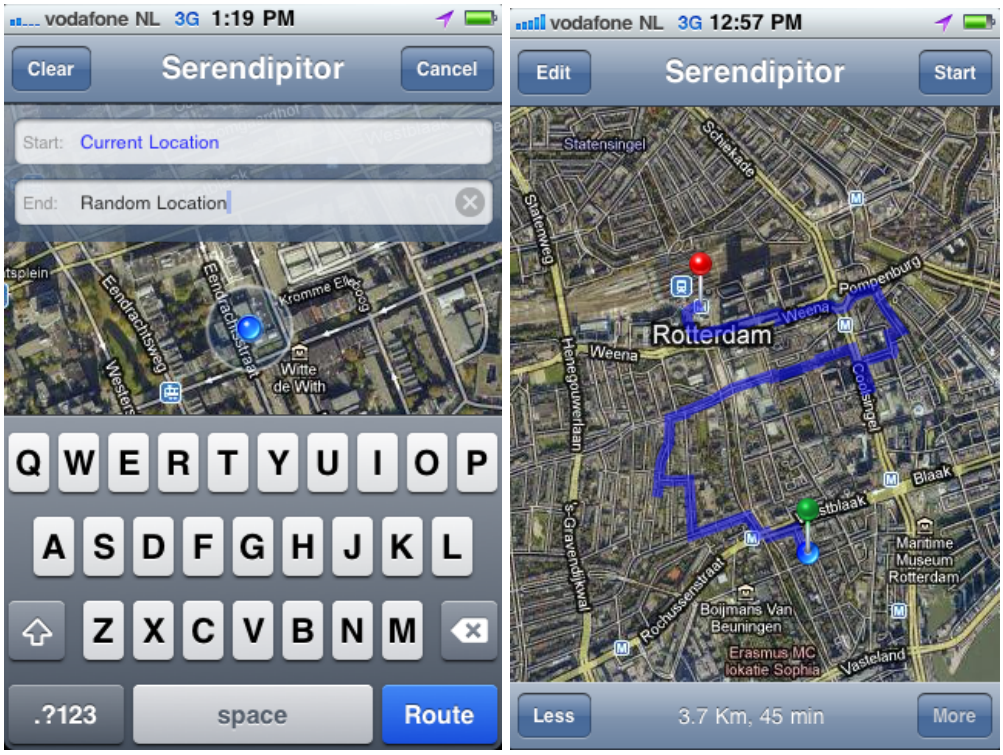

Fig 2. Screenshot of iPhone App *Serendipitor* by Mark Shephard, 2010

would have otherwise been out of sight. Unlike Google Maps, this app encourages meandering and discovery of new events, people, and places serendipitously. Thus, the efficiency of navigation apps is challenged allowing for novel ways of engaging with the city. The inseparable relationship between software and space, another feature of the post-digital, is highlighted by these projects. “Software and the spatiality of everyday life [has] become mutually constituted”[27] as a result of the proliferation of virtual map interfaces. In other words, geolocation technologies are not just tools to enhance our interaction with physical space, but they also create new forms of spatiality. For example, the use of Google Maps determines which streets are accessed the most and which roads are avoided by drivers. Bartholl and Shephard’s works hint at the influence of post-digital technologies on culture and society; namely Google Maps. However, the underlying geolocation systems are unexamined in these creative practices and their art is confined to the interface level.

[27] Rob Kitchin and Martin Dodge, *Code/Space: Software and Everyday Life* (Cambridge, Mass.: The MIT Press, 2014).

When considering the post-digital condition and analyzing the creative practices of Bartholl and Shephard, I saw a missed opportunity to look beyond the interface of contemporary virtual maps. Using my technical training, I engaged with the geolocation systems that enable virtual maps to perfectly align ‘one to one’ with physical space. I sidestep the interface and question the neatly packaged nature of what appears on the screen. I push visitors to be curious about the information and processes that drive virtual maps, which are now typically taken for granted and at face value. Specifically, in my installations and interventions, I created an opportunity to engage materially and experientially with the interaction between geolocation systems and the Stamps Gallery. I rely on the strategies of Systems Aesthetics and early net art to bring awareness to the obscure activities that happen behind virtual map interfaces as a way to reflect on post-digital sensibilities which are increasingly dematerialized.

Experiential Engagement & Systems Aesthetics

Through the creative works of my thesis, I set out to create opportunities to provoke thinking to acknowledge the system’s presence and articulate its complex interactions. Specifically, I wanted visitors to perceive and reflect on geolocation systems that are omnipresent in the Stamps Gallery; to comprehend the pervasive, yet invisible, network activity that enables virtual maps to interact with the physical space. The relationship between the WiFi & GPS infrastructure and Stamps Gallery is imperceptible and abstract. Even though a WiFi router has a tangible form, its physical attributes do not accurately represent the breadth of its operational qualities. I wanted to develop ways in which I could transform the intangible into the substantial. Thus, my installations and interventions are designed to provide a conceptual aesthetic

experience that expresses the way WiFi & GPS systems shape and inform spatial interactions through virtual maps.

To create such conceptual aesthetic experiences for my installations and interventions, I relied on the strategies of Systems Aesthetics. A term coined by the artist and critic Jack Burnham, Systems Aesthetics was best illustrated in a pioneering show he curated in 1970, *Software - Information Technology: Its New Meaning for Art*. First exhibited at the Jewish Museum in Brooklyn, NY, and then later at the Smithsonian Institution in Washington, D.C., this show brought together artists, engineers, designers, and architects to reflect on the fast-expanding cultural influence of information processing systems and devices. Unlike other art and technology exhibitions of the time, where technologies were seen and used as tools for creative production, this show presented "ideas of 'Software' and 'Information Technology' as metaphors for art."[28]

Burnham challenged participating artists to construct experiences that could enable visitors to engage with sensibilities that were novel to emerging information technologies of the time. The exhibition was void of traditional art objects, yet abundant in conceptual propositions. Even though visitors saw computers, servers, and other technical equipment in action, the aesthetic experience was driven by intangible and abstract notions of networks, data, and algorithms, i.e., the invisible. By putting technical equipment in an art gallery, visitors were thrown into what was thought of as quite contradictory and competing worlds. The tension between the two invited visitors to contemplate and question the roles and implications of information technologies rather than simply observing their physical manifestations.

[28] Jack Burnham, *Software - Information Technology: Its New Meaning for Art* (The Jewish Museum, 1970).

Interactivity was a method employed by some artists in *Software* that invited visitors to have an intimate experience with the technical systems exhibited. For example, participating artist Ted Nelson created *Labyrinth* where visitors could use a computer terminal to access an interactive catalog of the exhibition. “By choosing their own narrative paths through an interlinked database of texts,”[29] users could print out a personalized path through the gallery space. This enabled them to experience the exhibition on their own making as opposed to the predetermined path of the museum layout. Physically interacting with the computer terminal involved visitors in the production and expression of the *Labyrinth* system. The concept illustrated by *Labyrinth* was incomplete without user participation. It was dormant until brought to life through live engagement. It took the exhibit from experimental to experiential. Most importantly, it forced users to meditate on its ideas. Seeing themselves in the system, the implications of “dynamically linked text systems”[30] became personal. The strategy of taking a complex ethereal concept, and making it palpable is useful in helping people appreciate imperceptible systems such as WiFi & GPS infrastructures. I set out to achieve this grounding, and it’s why my installations and interventions are meant to be experienced through the smartphones of each visitor as they walk through the Stamps Gallery. By integrating the installations with the visitors and their smartphones, their engagement with the geolocation technologies can linger long after leaving the gallery. The smartphone is an individualized window through which visitors can contemplate the complex mechanisms occurring behind their screen and within their environment, long after they leave the gallery space.

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[29] “Systems Art - Systems Aesthetics and the System as Medium.”

[30] Edward A. Shanken, “The House That Jack Built: Jack Burnham’s Concept of ‘Software’ as a Metaphor for Art,” *Leonardo Electronic Almanac* 6, no. 10 (October 1998), https://www.semanticscholar.org/paper/The-House-That-Jack-Built%3A-Jack-Burnham's-Concept-a-Shanken/66c6d3a33b8c8297fc9ae0ac3d24edf999322175.

The conceptual artist Hans Haacke employed real-time networks as a means to engage with the conceptual ideas of information technologies. In *Software,* Haacke brought several teletype machines into the museum. His installation, titled *News* (fig. 3), included machines that would

Fig 3. Installation view of *News* by Hans Haacke at SFMOMA. Created in 1969 and acquired in 2008. https://www.sfmoma.org/artwork/2008.232/

print reports compiled from various local, national, and international news networks in real-time. By placing these machines in the museum space, visitors were confronted with a live stream of information that, at the time, was only available to them through evening broadcasts or a trip to the newsstand. The news printed in the gallery were actual reports being broadcast by news networks around the world. Through this gesture, Haacke created the opportunity to witness a real-world network in action. Thus, this installation articulated an aesthetic experience of networks that was hard to grasp at the time and remains difficult even today.

The operation of the teletype machines was crucial to this experience and it is only through viewing the physical printouts that visitors were able to comprehend the activity of real-time information exchange. This effect would have been diminished if the machines were presented as static objects or if the news reports were simulated. Relying on real-time information rather

than mimicking a network offered visitors a chance to witness the information exchange that occurs within computer networks. In a similar fashion, I visualize the WiFi & GPS networks that are presented in the Stamps Gallery. The expression of these networks in my installations and interventions is not simulated. Just as in *News,* live data is exposed, giving the visitors behind-the-scenes access to the WiFi & GPS infrastructure exactly as it exists in the gallery. The use of real-time networks is vital to my work, as it creates an environment of curiosity and introspection.

The use of didactic text and minimal visual design are also an important aspect of Systems Aesthetics. For example, the artist Robert Barry, known for using intangible materials to create artworks, was also a participant in *Software.* Barry, a son of an engineer, employs electromagnetic waves and inert gases to hint at what cannot be perceived and the power of such invisible, yet present, forces. In his piece titled Electromagnetic Energy Field (fig. 4), he created a battery-powered machine that "would send out waves of energy, filling the gallery space with an invisible, immeasurable, but nonetheless real force."[31] The use of an immaterial medium in this installation perfectly articulates the amorphous nature of networks, algorithms

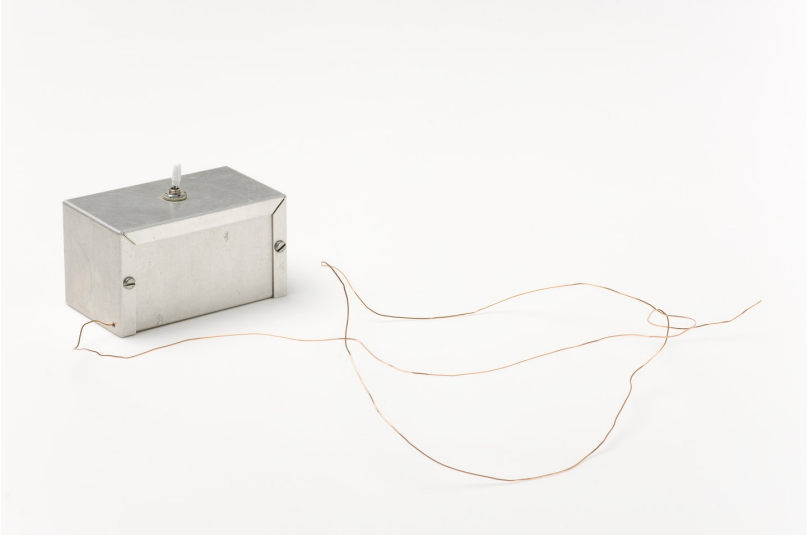

Fig 4. Photo of *Electromagnetic Energy Field* by Robert Barry, 1968. Owned by T. B. Walker Acquisition Fund, https://walkerart.org/collections/artworks/electromagnetic-energy-field

[31] Robert Barry, *Robert Barry: All the Things I Know But of Which I Am Not at the Moment Thinking - 1:36 PM ; June 15, 1969 : Stedelijk Museum Amsterdam, September 13 - October 20, 1974* (Stedelijk Museum Amsterdam, 1974).

and data. These strategies of Systems Aesthetics are similar to the goals of conceptual art where “idea or concept is the most important aspect of the work.”[32] The role of objects is to hint at the activity that can only be imagined in the mind. In Barry’s case, a placard in the gallery is all that exists to indicate to the visitors that they are surrounded by an invisible yet physical presence. The radio transmitter was hidden away from visual sight so that visitors were forced to contemplate where and how the invisible waves were working in the museum. I used this same approach of creating mental models to highlight the activity of the WiFi & GPS infrastructures in the Stamps Gallery. The minimal visual design of my installations and interventions aids in provoking visitors to imagine how the invisible WiFi & GPS electromagnetic fields interact with the gallery. Additionally, I use didactic texts to explain the technical mechanism of my installations and interventions, so the visitors can engage in ways in which WiFi & GPS systems shape and inform their spatial interactions with the Stamps Gallery. Systems Aesthetics provides methods to engage with abstract qualities of networks, data, and algorithms. Using interactivity, real-time networks, didactic text, and minimal visual design creates opportunities to engage with the operational qualities of digital systems. I find that these strategies are particularly helpful in engaging with systems that, in the post-digital, are entangled in every aspect of culture and society. Such an aesthetic experience provides a way to create the condition to engage with WiFi & GPS infrastructures that are otherwise obscured by digital interfaces. This heightens curiosity and invites introspection despite the intangibility of the networks that enable virtual maps to interact with the physical space.

[32] “Paragraphs on Conceptual Art,” accessed May 22, 2020, https://www.artforum.com/print/196706/paragraphs-on-conceptual-art-36719.

Materiality Engagement & Net art

WiFi & GPS infrastructures are core components of the technical foundations of post-digital societies. Seamless and real-time interactions with physical space through virtual maps are made possible through the ceaseless functioning of these infrastructures. While supporting mobility and rich user experience of smartphones, wireless technologies also create a gap between the everyday user and the material realities of WiFi & GPS. As wireless technologies have become commonplace, the experience of "wireless networks imply that there are fewer wires, [however] it could easily be argued that actually there are more wires."[33] WiFi & GPS infrastructures are comprised of routers, ethernet cables, satellites, etc., which all have a corresponding tangible and physical presence. By design, wireless technologies remove the need for wiring to the end-user and, thus, allow for connectivity over long distances, unencumbered by physical obstacles. There is always a tradeoff in the experience of materiality for the convenience of wirelessness. WiFi & GPS infrastructures remain out of sight in post-digital societies and a tangible experience of the technical infrastructure is withheld from the everyday user.

This notion of materiality is further obscured by the properties of WiFi & GPS signals. WiFi & GPS exist on the electromagnetic spectrum, and although physically present, are imperceptible. As opposed to following a wire to its source, the invisibility of these signals eliminates the visual cue to suggest that there is a network present. Today, everything from cars to clothing, and even our toilets are embedded with WiFi chips. It is estimated that by the end of 2020 there will be nearly 21 billion Internet of Things (IoT) devices around the globe.[34] Thus, our relationship with WiFi & GPS is akin to the relationship of a fish to water.[35] Fish have no conceptual

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[33] Adrian Mackenzie, *Wirelessness: Radical Empiricism in Network Cultures* (Cambridge, Mass: The MIT Press, 2010).
[34] "Gartner: 21 Billion IoT Devices To Invade By 2020," InformationWeek, accessed May 14, 2020, https://www.informationweek.com/mobile/mobile-devices/gartner-21-billion-iot-devices-to-invade-by-2020/d/d-id/1323081.
[35] Mark & de Kerckhove Derrick Federman, *McLuhan for Managers: New Tools for New Thinking*, 1St Edition edition (Toronto: Penguin Books, 2003).

understanding of water because they cannot perceive it. Despite WiFi & GPS infrastructures being embedded everywhere, their inherent qualities make them incomprehensible.

In my work, I challenge the intangible and incomprehensible experience of WiFi & GPS infrastructures by providing material engagement in two ways. First, I visualize the physical traces of the infrastructure embedded in the environment, specifically by calling attention to the WiFi routers that are scattered in and around the Stamps Gallery. Second, by relying on my technical training, I directly manipulate the invisible WiFi & GPS electromagnetic signals. These methods allow visitors to directly observe the material qualities of these unobservable WiFi & GPS infrastructures, thus, encouraging a critical awareness of these systems. I was inspired by early net art's approach to material engagement in provoking a better understanding of network systems through their use of HTML code as materials.[36]

The Belgian Dutch collective JODI takes a modernist[37] approach to HTML code by treating it as raw material that is conducive to manipulation and experimentation. Their creative practice stems out of a desire to challenge the widely accepted visual aesthetics of the Internet that have resulted from the wide adoption of web standards. Although the Internet in the '90s was in its nascent stages, it did not take long for it to evolve and grow. In the efforts to make the web accessible and enhance the user experience, HTML code was slowly drifting to the background and was being replaced by more dynamic and responsive features that relied on JavaScript. JODI's practice aims to manipulate the code behind web browsers to disrupt these widely accepted standardized features and experiences. For example, upon opening their most well-known net art piece https://wwwwwwwww.jodi.org/ (fig. 5), one is confronted with a screen full of gibberish in green text. At first glance, the webpage mainly consists of punctuation marks

[36] "What Is Net Art?," accessed May 24, 2020, https://netspecific.net/en/netspecific/what-is-net-art.
[37] "Jodi's Infrastructure - Journal #74 June 2016 - e-Flux," accessed May 5, 2020, https://www.e-flux.com/journal/74/59810/jodi-s-infrastructure/.

and numerals which seem to be rendered from an error. Instead, the visual artifact is generated as a function of how web browsers translate HTML code. Looking at the back end of the webpage, by clicking on ‘view source,’ a diagram of a hydrogen bomb in ASCII is unveiled “as if to explode expectations about the web as a medium.”[38] The visual effect is rendered by the

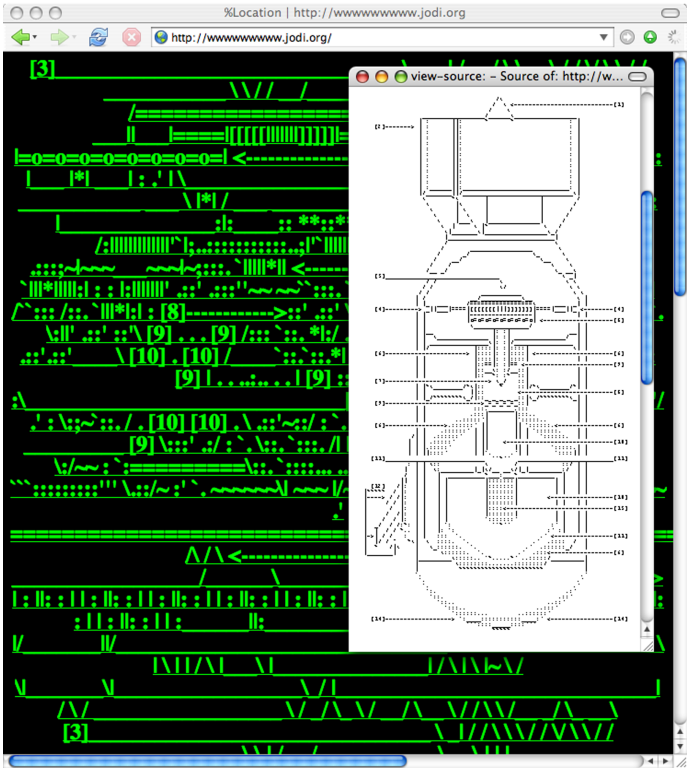

Fig 5. Screenshot of https://wwwwwwwww.jodi.org/ by JODI, 1995. https://rhizome.org/events/new-media-art-art-in-the-age-of-digital-communication/

browser’s inability to translate the ASCII text. While the source code is human-readable, once rendered by the browser, the form is distorted. It appears as garbled text even though the code behind the browser is perfectly legible. Through this experience, which is created by manipulating this underlying code, JODI aims to expose mechanisms that structure texts, images, and information to appear in the browser. In this way, viewers are empowered to explore the browser, its settings and configurations, beyond what is rendered on the screen. By challenging the habitual use of web browsers, JODI offers a “glimpse at the other possibilities

[38] Mark Tribe, Reena Jana, and Uta Grosenick, eds., *New Media Art* (Köln ; Los Angeles: Taschen, 2006).

for technology."[39] I found this method of tinkering particularly useful in developing my creative work. I approached the invisible WiFi & GPS signals, just as JODI did with HTML code. My engineering background enabled me to discover that these materials were open to shaping and molding. By manipulating the invisible electromagnetic waves, I disrupted the seamless experience of virtual maps, just as the experience of the browser was disturbed by JODI. This disruption provided an opportunity to view the WiFi & GPS signals as possessing material qualities. By transforming this intangible signal to palpable form, my work invites a greater awareness of the signals' presence and how they inundate the physical space of the post-digital.

Net art also provides a useful way to expose and visualize the network processes that are otherwise hidden. The Russian artist Olia Lialina is a practitioner who directly engages with the vernacular materiality of the Internet. Similar to JODI, she uses HTML code as a medium to expose the material processes of the Internet. Specifically, Lialina employs the distributed nature of the Internet to create her net art pieces. This medium specificity is a core feature in her practice and is always visible in her works. For example, *Summer* (fig. 6), consists of an animated GIF of Lialina swinging from the URL address bar in the browser. She is dressed in summer clothes and, as she swings back and forth, the animation is jittery. This irregularity is

[39] Leila Nadir, "Screens, Networks and Our Imagination," Hyperallergic, April 30, 2012, https://hyperallergic.com/50625/jodi-museum-of-the-moving-image/.

Fig 6. Screenshot of *Summer* by Olia Lialina, 2013, http://art.teleportacia.org/olia/summer/

not a glitch but a feature of the network that is exposed by the artist. The animated GIF has 21 frames, each being stored on a different server hosted by her friends. When viewing the animation, the browser pulls each frame from a different server. These servers are located in different parts of the world and so the time required to render each frame differs greatly. Thus, there is a lag in the animation signifying the browser's request to each of these 21 different servers. Additionally, the speed of Lialina swinging “depends on the connection speed [of each visitor]... and you can’t watch this GIF offline.”[40] Hence each viewer experiences a unique version of this work. Lialina’s *Summer* makes visible the network interactions that are hidden behind the browser. Her work adds a physical dimension to the experience of the Internet. The physical proximity of Lialina’s friends and their respective servers which store the images is

[40] Jillian Steinhauer, “Sometimes a GIF Is All You Need,” Hyperallergic, August 6, 2013, https://hyperallergic.com/77693/sometimes-a-gif-is-all-you-need/.

demonstrated by different loading times of each frame. There is a relationship between how far away the friend is and how fast each frame is loaded.

Engaging with the Internet through a browser limits the understanding of its physical footprint. One does not perceive the servers, cables, and datacenters. In fact, data centers are now responsible for 2% of all global greenhouse gas emissions.[41] The material impact becomes abundantly clear as Lialina swings back and forth in the browser. I create a similar effect to reveal the spatial and physical presence of WiFi & GPS infrastructures in and around the Stamps Gallery. WiFi & GPS, just like the Internet, are comprised of physical equipment. Routers, cables, repeaters, etc., are all part of this infrastructure and, by design, are usually hidden away from sight. Embedded in architecture, these physical devices provide seamless and consistent connectivity. I visualize their physical presence to provide a material engagement of WiFi & GPS. My installations and interventions thus make it possible to conceive of all the wireless hardware that is embedded in the physical space.

The Internet of today does not resemble its former self. It has spilled out from the confines of the desktop screen and as a result, “the online versus offline, or virtual versus real-life dichotomies, are undermined and hardly make sense anymore in developed societies.”[42] The supporting technologies of WiFi & GPS have been designed to provide maximum mobility and ubiquity. To achieve this, these systems have been purposefully designed to be invisible and hidden. In my creative work, I provide material engagement in two ways. First, I manipulate the signals to intervene in the seamless experience of virtual maps. This rupture creates an awareness of a change in the material properties of the signals behind the interface. Second, I expose the

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[41] Adam Vaughan, “Data Centre Emissions Rival Air Travel as Digital Demand Soars,” *The Guardian*, September 25, 2015, sec. Environment, https://www.theguardian.com/environment/2015/sep/25/server-data-centre-emissions-air-travel-web-google-facebook-greenhouse-gas.

[42] Christian Ulrik Andersen and Søren Pold, *The Metainterface: The Art of Platforms, Cities, and Clouds* (Cambridge, Massachusetts ; London, England: The MIT Press, 2018).

spatial and physical traces of WiFi & GPS hardware, creating an awareness of the surroundings that are being increasingly embedded with wireless systems. This visualization also allows visitors to imagine all the devices that are hidden behind buildings that interact with their smartphones. Applying principles of net art in these two ways allowed me to heighten the sense perception of WiFi & GPS in physical space.

Methodology

Making through Hacking

The overarching theme of my thesis has been to disrupt the normative experience of post-digital technologies as they mediate all forms of interactions with people, places, and things. Despite the concerted effort of technology companies to ensure that their products and services provide an effective and seamless experience, defects and failures appear in the technical designs and mechanisms. These bugs are "a byproduct of high levels of technical complexity"[43] that have come to characterize post-digital technologies. Because these systems tend to be proprietary in nature, no readily available manuals or schematics exist that allow for thorough technical understanding. Hacking, the process of identifying bugs, allows for deeper insights into the technical mechanism of systems that are obscured in post-digital societies.

While these bugs are viewed as anomalies by engineers and designers that need to be fixed or patched, I view them as opportunities to "produce new meanings."[44] The discovery of bugs, in addition to expanding my technical understanding, helps in guiding future steps, processes, and experiments in my creative practice. The bugs that I find, either through the process of tinkering or researching IT security forums and blogs, provide an opportunity for pausing and contemplating. I consider hacking as a form of "reflection-for-action"[45] in my practice-based research. Hacking allows me to develop distinct threads that can be further investigated. These threads either directly lead to the development of specific installations or interventions or provide additional opportunities for material, i.e., software and hardware experimentation. Hence I approach hacking as a way for generating ideas and exploring unanticipated

[43] Alexander R. Galloway and Eugene Thacker, *The Exploit: A Theory of Networks*, Electronic Mediations, v. 21 (Minneapolis: University of Minnesota Press, 2007).
[44] McKenzie Wark, *A Hacker Manifesto* (Cambridge, MA: Harvard University Press, 2004).
[45] Linda Candy, *The Creative Reflective Practitioner: Research Through Making and Practice* (Routledge, 2019).

outcomes.[46] Hacking, in particular, helps in "identifying the kinds of constraints"[47] that allow for narrowing the scope and clearly articulating the ideas behind my creative works. Hence, I use hacking as a way to discover what experiences can be created with the various devices, systems, algorithms, etc., that I wish to highlight or expose in my work.

My background in engineering provides me with the tools and methods to look at specific areas to find and exploit bugs for my creative practice. Whether it is reading lines of code, browsing Google's Application Protocol Interface (API), or scanning electronic circuitry, these methods allow for understanding the functionality of systems that are otherwise difficult to ascertain. For example, in this thesis I experimented with invisible WiFi & GPS electromagnetic signals through an open-source tool called Software Defined Radios (SDRs). SDRs are devices that can transmit and receive data over specific radio frequencies. They can be programmed to hijack the GPS signals of smartphones. Playing with SDRs to manipulate the GPS signals and experimenting with multiple smartphones led me to create virtual traffic jams on Google Maps. This insight was used in other experiments that enabled me to disrupt the seamless experience of virtual maps. Additionally, tinkering with SDRs opened up another thread of investigation in which I approached the electromagnetic waves as a material. Using electromagnetic fields (EMF) fabric, I was able to physically block and attenuate WiFi & GPS signals. This feature of EMF fabric was extensively used in the creative works for this thesis.

Making through Iteration

Once concrete threads have been generated either by hacking or through other conventional research methods, I use an iterative making methodology to transform abstract ideas into final

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[46] William Goddard and Robert Cercos, "Playful Hacking within Research-through-Design," in *Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction on - OzCHI '15* (the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction, Parkville, VIC, Australia: ACM Press, 2015), 333–37, https://doi.org/10.1145/2838739.2838802.
[47] Candy, *The Creative Reflective Practitioner*.

forms. The iterative process consists of building prototypes, testing, and then updating the prototypes based on evaluation. Prototyping allows me to set my ideas into action by creating a physically tangible way to engage with concepts. Prototyping, which takes on many forms such as functional models, sketches, wireframes, or mockups, also enables me to "reflect in the moment of making."[48] Once a prototype is made, I test its functionality and aesthetic qualities to evaluate its efficacy. Specifically, I aim to understand how the prototype can be updated, changed, augmented, etc. so that it appropriately communicates the ideas that I wish to convey in my creative outputs. I achieve this in two ways: by inviting others to provide direct feedback and through my own reflective process. Once a prototype has been made, this process of evaluation enables me to critically "reflect at a distance"[49] to determine specific steps and help guide the decisions of my making process.

This iterative process is critical in my creative practice and enables me to transform the 'unknown to the known' through "purposeful yet open-ended, clear-sighted yet exploratory"[50] methods. The creative works in this thesis are designed to provoke visitors to explore the systems behind virtual map interfaces. I aim to humanize, de-code, and de-mystify this information to invoke a sense of curiosity similar to that which inspired me as a child to pry open electronics. Thus, the iterative process enables me to imagine, design, and build installations and interventions keeping the point of view of the average user in mind. By 'seeing' from the spectator's perspective, the iterative process enables me to challenge common perceptions of technology. I gain insights through feedback and reflection that enable me to fine-tune the conceptual and visual aspects of my work. This cyclical process "whereby imaginative leaps are

[48] Ibid.
[49] Ibid.
[50] Hazel Smith and Roger Dean, eds., *Practice-Led Research, Research-Led Practice in the Creative Arts*, 1 edition (Edinburgh: Edinburgh University Press, 2009).

made into what [I] don't know...can lead to critical insights."[51] These findings have been crucial in developing

engaging experiences for the everyday consumer of GAFAM technologies to grasp and comprehend geolocation systems.

The site-specific installations and interventions for this thesis were developed through several cycles of prototyping, testing, and updating. I spent significant time in the Stamps Gallery collecting WiFi signals and surveying the physical presence of WiFi & GPS infrastructures. The prototypes created from this data were then tested with other students, faculty, and creative people in the community. This empirical feedback resulted in the refinement of designs of the creative works. In some cases, based on reactions I added interactive components to my installations. In other cases, I relied on the use of didactic texts to improve visitor accessibility. I also tested the prototypes in the gallery through the use of masking tape to mark out my installations. I documented these mockups through photographs as a way to "respond to [my] intuitive instincts"[52] on how to update, change, and improve the designs and experience of my installations and interventions.

Making through Conceptual Sketching

While sketching aids in the prototyping process, I also rely on it as a way to clarify and develop conceptual ideas in my creative works. Specifically, I use sketching as a way to "think with and through drawing to make discoveries, find new possibilities that give course to ideas and help fashion their eventual material or conceptual form."[53] By translating my mental models of complex technical systems to paper, I am able to visualize its various components and subsystems. Each of these components enables me to explore the technical system from

[51] Smith and Dean.
[52] Candy, *The Creative Reflective Practitioner*.
[53] Terry Rosenberg, "New Beginnings and Monstrous Births: Notes towards an Appreciation of Ideational Drawing," January 1, 2007.

different perspectives and provide opportunities for future experimentation and examination. Thus conceptual sketching enables me to generate concrete ideas that help in the development of my installations and interventions.

The geolocation systems that are behind virtual map interfaces are inherently abstract. The network, data, and algorithms that make up the systems do not possess physical forms. The challenge in this thesis has been to provide creative ways to experience the operational qualities of geolocation systems. Conceptual sketching provides a practical way to brainstorm various ways of developing different aesthetic strategies for engagement. By sketching its elemental part and visualizing their relationships, I am able to select specific areas in the geolocation system that are "perceptually ambiguous."[54] This process of synthesizing and actualizing provides entry points into future experiments, material investigations, and prototypes. Similar to how I use hacking to discover bugs, conceptual sketching is a practice of "reflection-for-action"[55] discovery. This produces a blueprint upon which I can continuously reflect, build, and evolve.

[54] Welby Ings, "Drawing as Thought: Ideation in Narrative Film Design," *Artifact* 3 (December 31, 2014): 2, https://doi.org/10.14434/artifact.v3i2.3983.
[55] Candy, *The Creative Reflective Practitioner*.

Creative Work

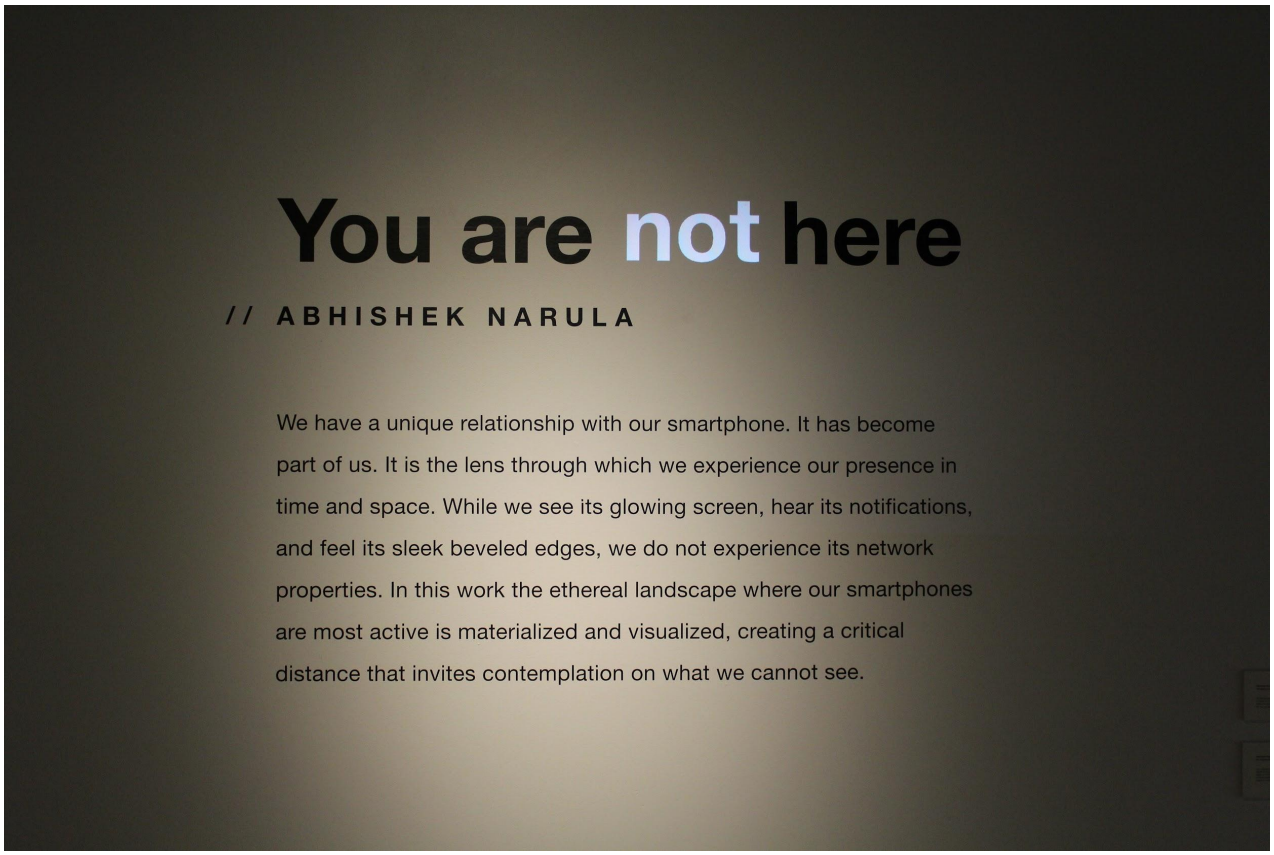

Fig 7. *You are not here*, 2020. View of didactic text.

Street Signs

Street Signs in an interactive installation in which visitors are invited to place their personal smartphones on a radio antenna mounted to the floor. Upon doing so, the radio antenna scans its surroundings for WiFi routers and projects the findings in the form of “street signs” on a wall. WiFi routers that are in close proximity to the spectator appear as larger signs, while smaller street signs indicate that the signal is emanating from a router located farther away from the gallery. Additionally, each street sign comes into view at different speeds. A high operational WiFi router appears on the wall sooner compared to routers that are not being used as much.

This interactive installation exposes the invisible WiFi signals that are detectable within a 0.5-mile radius of the spectator's standing position. In dense urban areas, buildings, trees, and other structures interfere with GPS signals that are usually used for geolocation purposes. Due to these physical obstructions, our smartphones instead rely on the location of WiFi routers. This built-in feature ensures that smartphones can use geolocation apps like Google Maps, Uber, Yelp, etc. even when in locations of attenuated GPS signals. The expanded use of wireless internet in homes, offices, and cafes has meant that our urban landscape is increasingly populated with WiFi routers. Even though we cannot always visually see these WiFi routers, our smartphones are able to perceive them through walls and buildings. Thus WiFi routers, in addition to providing internet connectivity, also act like geographic anchors for our smartphones.

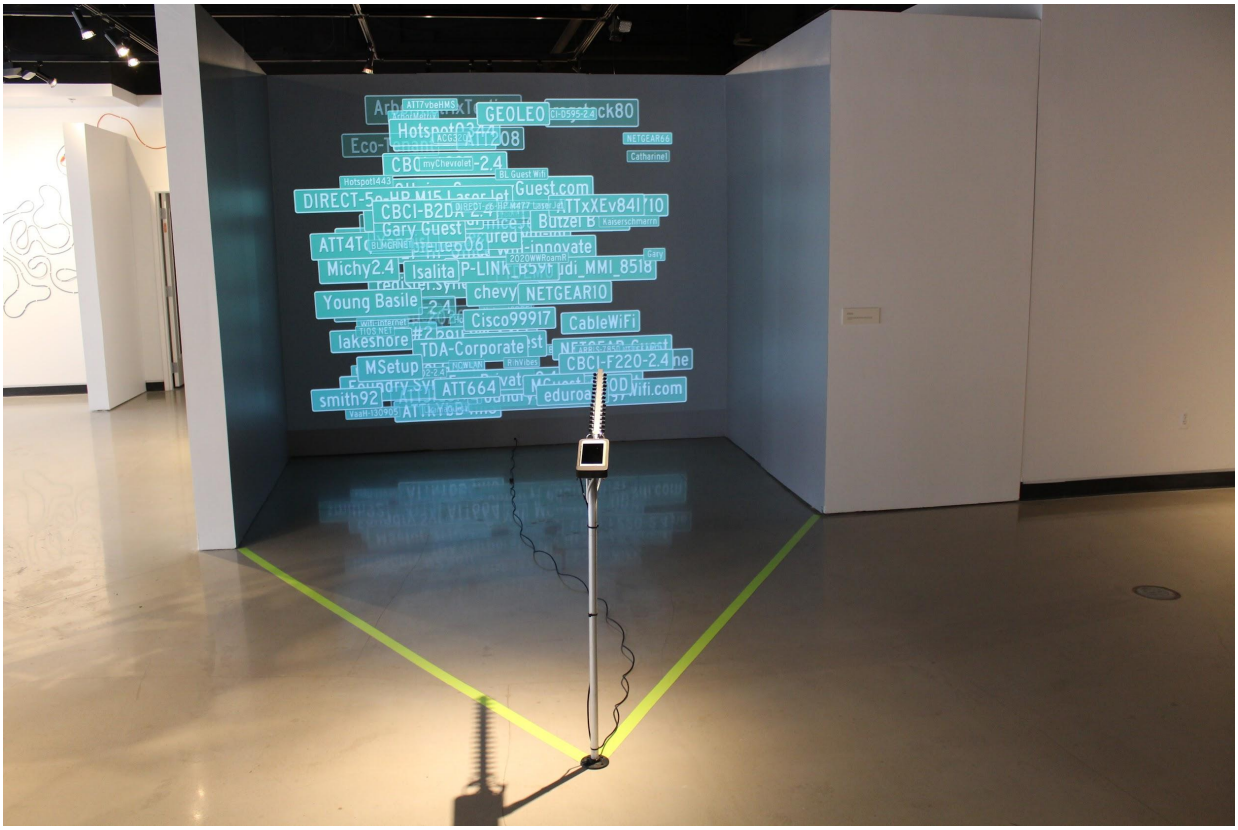

Fig 8. *Street Signs*, 2020. Installation view.

In *Street Signs,* I give form to these imperceptible interactions that occur between our smartphones and the numerous WiFi routers scattered across urban spaces. By depicting this

as a landscape, from the perspective of the smartphone, this installation exposes how WiFi routers are used for geolocation purposes. When triggered by visitors, the WiFi signals detected by the antenna gradually appear, as street signs in real-time on a projection directly in front of the spectator. As these signals are detected, captured, and displayed, the spectator is made aware of the vast, yet invisible, landscape around them, one that is only observable by their smartphones.

Just as we use street signs to get our bearings in urban areas, these invisible WiFi signals are meant to orient our smartphones. Thus, I display the WiFi networks' names so that they appear in the form of street signs, in the classic green background and silver font. I also use the visual language of first-person perspective to display the WiFi routers on the wall. I use interactivity in this installation as a way to give visitors a glimpse of how their personal smartphone is in constant interaction with its surroundings. The real-time electromagnetic landscape that unfolds on the wall is from the point of view of each visitor's smartphone. Thus, visitors are invited to recognize the invisible interaction between themselves, their smartphones, and the environment that enables the mechanism that we universally use to determine where we are.

Run Router Run

Run Router Run consists of a WiFi router mounted on an 80-foot track in the ceiling of the Stamps Gallery. This WiFi router moves back and forth between two locations, each time it gets registered by Google's geolocation database. This movement prevents Google from accurately determining the router's geographic location.

While *Street Signs* exposes an invisible landscape of WiFi routers, *Run Router Run* demonstrates how this digital landscape is formed and maintained. As we go about our day, our smartphones continuously scan and report the coordinates of WiFi routers back to Apple &

Google. This spatial probing occurs quietly, unbeknownst to the vast majority of smartphone users. Perhaps more unexpectedly, this continues even when our smartphones are idle. These databases of WiFi routers, serving as fixed locations and landmarks, help to create and maintain a virtual map of physical space around the globe.

Fig 9. *Run Router Run*, 2020. View of router mounted on track.

In order to reveal this obscure mapping process, I gave one of these fixed landmarks the ability to move. In *Run Router Run,* this movement disrupts the real-time scanning and reporting, thus limiting the reliability of the mapping process. I mounted a white Cisco Aironet CAP36021 WiFi router (fig. 9), a typical device for the University of Michigan, to an 80-foot track in the gallery's ceiling. Google provides access to its WiFi database through its geolocation application program interface (API) to make the router's evasive movement possible. However, Apple does not provide the same access. So for this installation, I wrote a program that continuously queries

Google's WiFi database to check when my installed router gets discovered. Once the router location in

Google's database matches the geographic coordinates printed in yellow vinyl on the floor directly below the router (fig. 10), my program moves it to the other end of the gallery. The router, in other words, perpetually dodges capture. The movement of the router is directly tied to the presence of people and their smartphones in the exhibition space. As more and more people visit the exhibition, the chances of the router being discovered increases and, correspondingly, so does its frequency of motion.

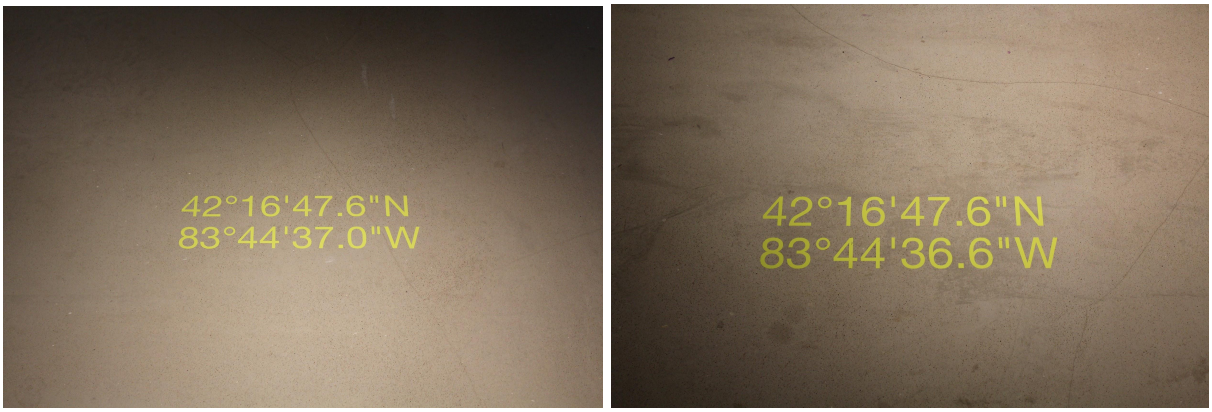

Fig 10. *Run Router Run*, 2020. View of geographic coordinates in yellow vinyl.

The work is visually present in two places: the way the gallery is represented on virtual maps as well as the physical installation in the gallery. The variable position of the WiFi router causes a visual fluctuation in the reading of the gallery's location, causing the location of the gallery to shift on virtual maps. In the gallery, the router slowly crawls back and forth on the track embedded in the ceiling, for 80 feet, between two defined points. This 80-foot distance was the longest possible unobstructed straight line available to mount the track to the ceiling infrastructure. It traipses along, almost out of sight, amidst the existing architectural infrastructure of venting, lighting, and electrical conduit. On the floor of the gallery, the endpoints

of the path are correspondingly marked in yellow vinyl, hinting at the event occurring above the viewers' heads. The subtlety of this installation is deliberate, like the ubiquitous mapping that occurs without notice.

Ctrl-C Ctrl-V

Ctrl-C Ctrl-V is an interactive installation in which visitors are invited to enter a cuboid framed structure (10 X 15 X 8 ft) warped electromagnetic field (EMF) shielding fabric. Once inside, visitors see a prompt to open Google Maps on their smartphones. Upon doing so, Google Maps indicates that they are standing inside my studio, several miles away from the Stamps Gallery.

In *Ctrl-C Ctrl-V*, I wanted to engage with the invisible WiFi fields in a tactile manner.
Hence this installation examines the materiality of the physical signal between the WiFi router and the smartphone. WiFi signals are invisible electromagnetic fields that radiate in all directions through the air, therefore imperceptible and perhaps incomprehensible. Due to WiFi's ethereal quality, humans cannot distinguish visually or spatially between all of the various WiFi signals in any given space. In the gallery, I wanted to make the WiFi waves thinkable. In *Ctrl-C Ctrl-V*, I introduce foreign WiFi waves in a manner in which they remain separated from the waves of the exhibition space. As a result, WiFi waves become tangible as they coexist in the gallery, separated by a distinct boundary.

In this installation, the fabric structure defines a volume of 1,200 cubic feet in the gallery with the same scale as my personal studio. Inside, I placed a radio antenna that continuously replays WiFi signals that have been captured from my studio. The EMF shielding fabric traps these signals inside the structure and prevents them from dissipating throughout the gallery. Just as air molecules diffuse and conform to the shape of a rubber balloon, my studio WiFi signals conform to the volume of the fabric structure. As visualized earlier in *Street Signs*, WiFi signals

are used as landmarks by our smartphones. In order to engage with the WiFi waves from my studio, visitors enter the structure and open Google Maps. The presence of my personal WiFi waves tricks their smartphones and Google Maps indicates that they are located inside my personal studio.

Fig 11., *Ctrl-C Ctrl-V*, 2020. External view of EMF fabric structure.

The fabric structure creates a distinct boundary that delineates my studio waves from the waves that are native to the gallery. As visitors enter the structure, they physically transition in two unique and dynamic ways. They shift from an outside state to an inside state as well as from being immersed in the ambient WiFi signals of the gallery to the ambient signals of my studio. To keep the focus on the ethereal nature of the waves that fill the void inside the structure, I made deliberate efforts to ensure minimal aesthetics. Aside from an antenna and a vinyl text prompt to open Google Maps, there are no other visuals inside the fabric structure (fig. 12). Through this absence of perceptible activity, I wanted to make the spectator aware of the

invisible presence of WiFi waves that are floating within the structure. The presence of the transplanted electromagnetic waves are made evident through the visitor's smartphone. As a result, transplanting WiFi waves also conceptually serves to temporarily situate my studio in the gallery space.

Fig 12. *Ctrl-C Ctrl-V*, 2020. Interior view of structure showing radio antenna.

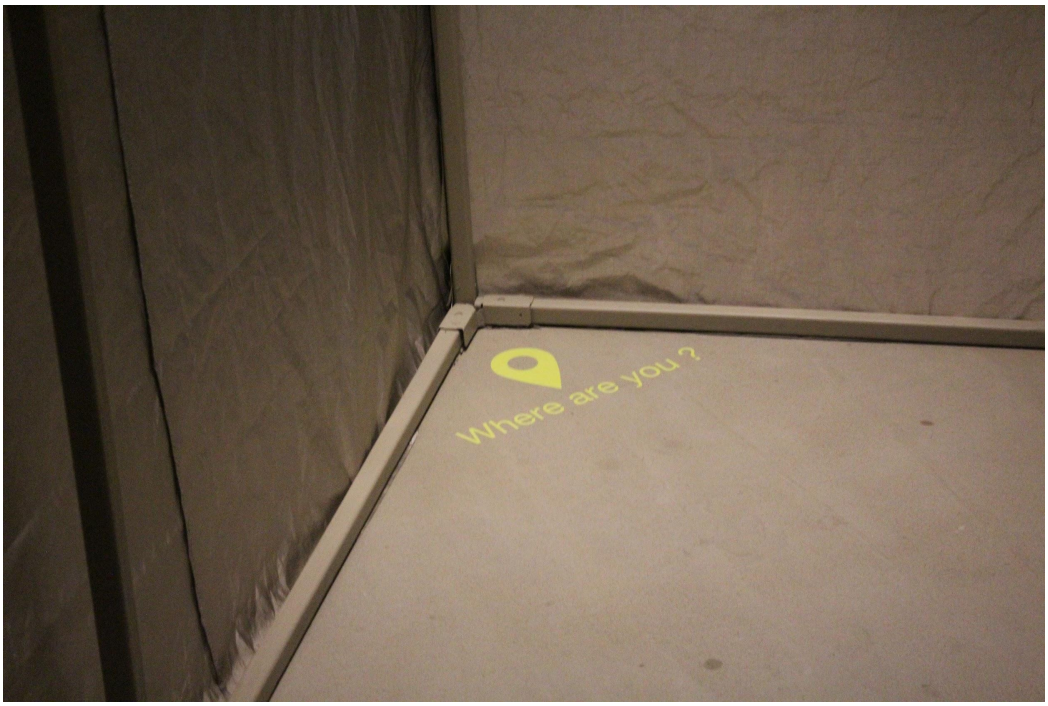

Fig 13. *Ctrl-C Ctrl-V*, 2020. Interior view of structure showing text prompt on floor.

The Network Speaks

The Networks Speaks consists of a number of smart plugs installed in the power sockets of the Stamps Gallery. Located roughly 18 inches from the ground, these smart plugs blend in with the technical infrastructure of the gallery, just like the router in *Run Router Run.* While visually static, upon closer inspection, visitors hear an audible click emanating from the plugs at seemingly random intervals.

In the installation, I expose the ambient WiFi activity in the gallery. Many smartphone users have the impression that their devices only connect to the internet when actively using a browser or an app. On the contrary, devices continuously make network requests in the background even when they appear idle. This background activity ensures that smartphones are constantly

updated. In this installation, I wanted to challenge the belief that our devices are inactive until we interact with them.

For *The Networks Speaks*, I modified the code of three off-the-shelf smart plugs and installed them in the power sockets of the gallery (fig. 14). These smart plugs have a mechanical relay that makes an audible click when activated. I made changes to the software so that it would monitor devices connected to the WiFi network of the gallery. In response, the smart plugs click every time one of these devices makes a network request. At first glance, they may appear to be malfunctioning, but upon reading the installation description, the clicking sound articulates the uncanny level of network activity in the gallery.

Fig 14. *The Network Speaks*, 2020. Installation view.

I placed the plugs throughout the gallery so that their clicking sounds would fill up the exhibition space. Even when the plugs are not visually accessible, the clicking soundscape reminds visitors of the constant inconspicuous conversation that happens between devices and the

gallery WiFi network. I used off-the-shelf smart plugs because of their compact form factor. By retrofitting the existing gallery infrastructure, I was able to distribute the plugs throughout the exhibition space. Hence, the plugs enable me to give the gallery WiFi network a voice. Instead of functioning as control devices for appliances, the smart plugs become sensors that speak to visitors, inviting them to listen in on the network chatter of the gallery.

The gallery has been moved 2 minutes away

The gallery has been moved 2 minutes away is an intervention in which I created a virtual traffic jam on the street directly in front of the Stamps Gallery. As a result, visitors navigating to the gallery using Google Maps for the opening would have noticed that their journey has been extended by 2 mins due to the congestion (fig. 15). I placed 40 smartphones in my studio (fig. 16). Using custom code and hardware, I manipulated their GPS signals so that they all appear

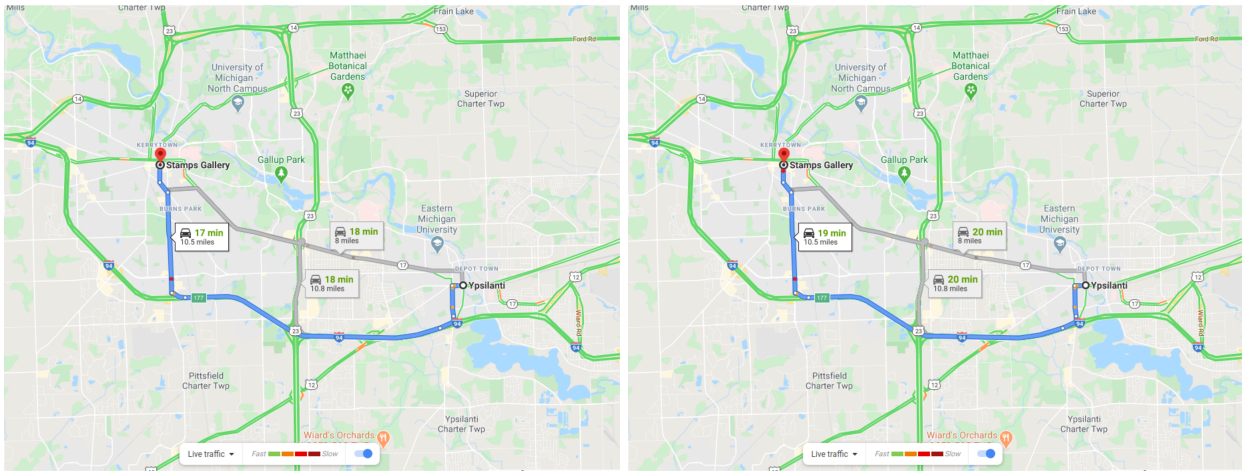

Fig 15. *The gallery has been moved 2 minutes away*, 2020. Before and after view of Google Maps indicating traffic jam.

to drive at 10 mph on Division St. in front of the Stamps Gallery. As they drive back and forth, a traffic jam materializes on Division St. on Google Maps. This traffic jam persisted for the duration of the opening of the exhibition. Visitors that used their smartphones to navigate to the MFA thesis show experienced this intervention on Google Maps.

The installations and interventions described above directly engage with the ubiquitous, spatial, and material nature of electromagnetic waves of the gallery. In this piece, I intervene in the relationship between the visitor and their smartphone by directly manipulating GPS waves. I want users to look at their phones differently and consider the faith and trust that they place in mobile devices. I do so by disrupting the gallery's representation on virtual maps, and in particular, how the visitors navigate to the gallery using Google Maps.

Fig 16. *The gallery has been moved 2 minutes away*, 2020. View of hacked smartphones located offsite.

While some visitors experienced the congestion in front of the gallery on Google Maps before arriving at the exhibition, they were only made aware of my intervention once they entered the gallery. A placard describing the mechanics of the intervention revealed that their experience of the virtual traffic jam was not accidental. The subtlety of this intervention is deliberate and mimics the ephemeral nature of GPS waves. Additionally, by manipulating the invisible medium

of GPS signals, I exposed how virtual cars can be added to virtual maps. Even though 40 smartphones were located at a remote site, I wanted visitors to look outside and imagine 40 virtual cars driving by the gallery. This installation demonstrates how a presence on virtual maps has a corresponding impact on the physical reality of our environment. Furthermore, the presence and absence of objects in space can be mitigated by technology. As with other installations and interventions in this show, I wanted to disrupt the relationship between the visitor and their smartphone.

Disappearing Act

In *Disappearing Act*, I provide visitors a way to radically disconnect from the network matrix of the gallery. I made small pouches using the same electromagnetic field (EMF) shielding fabric found in *Ctrl-C Ctrl-V.* Visitors are invited to place their smartphones in these pouches as they walk around the exhibition space. As a result, all electromagnetic fields are cut off from smartphones, rendering them useless. Once WiFi & GPS signals are blocked from reaching the smartphone, visitors can take solace in the fact that they are invisible. Similar to how electromagnetic waves are imperceptible to humans, this simple gesture allows visitors' smartphones to evade the gaze of the gallery network.

Fig 17. *Disappearing Act*, 2020. Image of smartphone inside EMF pouch.

Conclusion

My research was motivated by a need to create a space for critical reflection on the post-digital condition wherein the experiences of digital technologies are increasingly dematerialized. As digital technologies get entangled with every aspect of our lives, they evade curious examination. Despite their omnipresence, the average user does not engage with or wonder about the technical systems that are behind their devices. These devices are specifically designed to provide a rich user experience of flexibility and real-time interaction. However, in doing so, these technologies mask the complex networks, algorithms, and infrastructure that enable their functionality. While the obscuring of these systems is a conscious design decision, one that provides seamless interaction between people, places, and things, this obscurity becomes a feature of culture and society.

This is why I created site-specific installations and interventions that provided opportunities to engage with technical systems that are obscured by the design of smart devices. I initiated this research by examining various creative and visual practices that employ digital technologies. Beginning with contemporary creative technology practices, I examined works that engage with virtual map interfaces. Through my analysis, I argued that while these practitioners are able to articulate our dependency and sometimes even challenge the logic of virtual maps, they do so only at the interface level. As an artist with a background in engineering, I saw an opportunity to sidestep the interface and highlight the underlying geolocations systems that are hidden behind virtual map interfaces. To create such experiences, I studied the strategies of Systems Aesthetics and early net art. These practices see the role of technology as being more than just a tool for creative production. Rather, these practitioners approach technology as a medium that generates novel aesthetic possibilities that are otherwise not present in traditional artistic media. Specifically, the works examined in my research expose and highlight the often overlooked

aesthetics of digital technologies through creative practice. In particular, Systems Aesthetics uses interactivity, real-time networks, didactic text, and minimal visual design to provide spectators the ability to comprehend the abstract nature of software and information technology. Net artists attempt to engage with the HTML code as an artistic material. By directly manipulating HTML code, these practices build a critical awareness of the network infrastructure.

In my creative work, I used these strategies to materialize the geolocation system behind virtual maps interfaces. Through my installations and interventions, I seek to provide experiential and material engagement with how WiFi & GPS function to mediate the relationship between users and their physical environment. These creative strategies enable users to "explore this universe, initially triggering responses inadvertently, then gradually becoming more and more aware"[56] of the system that they rarely get to interact with. I found opportunities to use the geolocation system in artistic ways in order to render it approachable, tangible, thinkable, and vulnerable to manipulation. The creative works in my thesis specifically confront WiFi & GPS because these are the technical foundation for geolocation systems that are obscured by virtual map interfaces. These geolocation systems provide mobility and flexibility to interact with physical space by taking advantage of cloud computing. In cloud computing, the majority of information storage and processing occur away from users' devices. Algorithms running on remote servers process data collected from smartphones and relay back relevant geolocation information in real-time. WiFi & GPS ensure that this interaction can occur at any time and at any place. Thus, for me, WiFi & GPS articulate the dematerialized experience that has "become[s] a potent metaphor for the way contemporary society organizes and understands itself."[57]

[56] Myron K. Krueger, *Artificial Reality 2*, 2 edition (Reading, Mass: Addison-Wesley Professional, 1991).
[57] Hu

I believe that engaging with the messy technical mechanism behind our sleek devices is important for post-digital societies. The products and services offered by GAFAM provide great conveniences for contemporary life. However, despite our reliance on GAFAM technologies, most users have little understanding of how they work which, at best, limits engagement and, at worst, diminishes user agency. We are seduced by their sleek offerings and products and most do not bother to peek under the hood. This complacency leads to a black box society,[58] wherein so much of our world works in mysterious ways. Users of GAFAM technologies are able to use their services without needing to fully understand their inner workings. Thus, is it not possible to fully comprehend how GAFAM technologies affect us because “we cannot understand, or even investigate, a subject about which nothing is known.”[59]

This creates a gap in knowledge and understanding of the world and so digital technologies take on mythological dimensions.[60] Through my creative work, I strive to demystify digital technologies by heightening users' sense perception of hidden and obscured technological systems. By experiencing the system phenomenologically, users can gain an understanding of the processes that are continuously happening behind and outside the scope of their awareness. Perceiving technology this way can undermine the “absolute assertions about [GAFAM interfaces]...and also to envision alternatives.”[61] My creative work does not explicitly explain the functionality of WiFi & GPS systems. Rather, it provides a way to bring critical awareness and transparency to systems that are purposefully designed to be invisible. But this “transparency is not just an end in itself, but an interim step on the road to intelligibility.”[62]

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[58] Frank Pasquale, *The Black Box Society: The Secret Algorithms That Control Money and Information* (Cambridge, Massachusetts: Harvard University Press, 2016).
[59] Ibid.
[60] Ibid.
[61] Christian Ulrik Andersen and Søren Pold, “Interface Mythologies – Xanadu Unraveled.”
[62] Pasquale.

Winston Churchill once said, “we shape our buildings and afterwards our buildings shape us,”[63] and I believe the same is true for the digital ecosystem we find ourselves in today. Unlike the built environment, our digital ecosystem is characterized by obscurity and invisibility. In order to truly appreciate how technology shapes us, we should hope and demand that technology “of the future be made visible.”[64]

[63] “Churchill and the Commons Chamber,” UK Parliament, accessed May 15, 2020, https://www.parliament.uk/about/living-heritage/building/palace/architecture/palacestructure/churchill/.
[64] AuthorMedia Theory, “Olia Lialina: Once Again, The Doorknob,” *Media Theory* (blog), July 17, 2019, http://mediatheoryjournal.org/olia-lialina-once-again-the-doorknob/.

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