Morse Things: A Design Inquiry into the Gap Between Things and Us

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ABSTRACT

Applying a thing-centered, material speculation approach we designed the Morse Things to acknowledge and inquire into the gap between things and us. The Morse Things are sets of ceramic bowls and cups networked together to independently communicate through Morse code in an Internet of Things (IoT). We deployed the Morse Things in the households of six interaction design practitioners and researchers for six weeks. Following the deployment, we conducted a workshop to discuss the role of the Morse Things and ultimately the gap between things and people. We reflect on the nature of living with IoT things and discuss insights into the gap between things and humans that led to the idea of a new type of thing in the home that is neither human-centered technology nor non-digital artifacts.

Author Keywords

Things; Material Speculation; Internet of Things; Postphenomenology

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION

The Morse Things project investigates the nature of living with everyday things that are networked together and communicate in what is commonly understood as the Internet of Things (IoT). In particular, we investigate IoT from a thing-centered perspective in order to explore the gap between things and us. We designed and fabricated six sets of networked ceramic bowls and cups (Figure 1) to be given to domain expert participants – professional designers and design researchers – to live with for several weeks.

In human-computer interaction (HCI) research there is a long trajectory of research beginning with ubiquitous computing [1] towards smart homes [23] to IoT in the home [3] to an extension of visions of ubiquitous computing [4].

Figure 1 A set of Morse Things and a single medium bowl

IoT promises to reconfigure our everyday environments by providing connectivity to and between things, buildings, the city and beyond [3]. IoT also imagines the disappearance of computing into our everyday lives and infrastructures [1].

The emergence of IoT has led to critical reflections on the relationship between technologies and humans. For example, De Roeck et al. point out that users "need to have the power and control over the creation and use of applications for smart environments" [11:170] in order for IoT to be more widely adopted. In another example, the IoT Design Manifesto [2] adopts a critical yet ultimately idealistic approach to IoT. The collective of designers and design researchers behind the manifesto advocates for key human principles to be brought to bear on the design of IoT systems. These examples reflect the vigilance of the human-centered orientation and the value the orientation brings to designing IoT systems [10,45,49]. In many respects, a human-centered approach aims to close the gap between humans and technologies in order for IoT to better serve human needs–a goal not being challenged here. Yet, what might a human-centered approach hide with respect to the relations we have with technology? Our adoption of a thing-centered approach in the Morse Things project begins with this question. Stated in the positive, what might be revealed in the relations we have with technology through a thing-centered approach to IoT?

Our generative approach with the Morse Things is an inquiry into the complexity of our relationship with things. In particular, we inquire about the gap between things and us. This gap results in somewhat of a conundrum that we simultaneously cannot understand what it is to be a thing, yet we would not be able to function in or comprehend our lives without things.

The contributions of this paper include an empirically derived description of experiencing the gap between IoT things and us. In particular, we describe the challenges of relating to things, new forms of attachment to technological things in our everyday lives, and a possible new type of thing in the home that is neither human-centered technology nor non-digital artifacts.

BACKGROUND

In the following sections we provide a background for the Morse Things. We position our thing-centered approach to connected artifacts as a way to investigate human-technology relations. We discuss related work in the area of IoT, and discuss related philosophies of technology and thing perspective research in HCI.

Internet of Things

The IoT is concerned with the design of internet-connected interactive artifacts enabled to collect and exchange data. The IoT development has emerged as an extension of ubiquitous computing [48] and pervasive computing [40] and is seen as a new way of thinking about connected technologies [31]. The IoT directly connects our physical world with computer-based virtual networks. Some examples include smart home devices (e.g. Philips Hue, Nest, Honeywell), wearables (e.g. Apple watch, Fitbit, Jawbone), smart cities, and connected cars.

However, concerns and critical thoughts have been raised about IoT. While the IoT broadens information access and empowers citizens, it also threatens privacy and autonomy and potentially enables social and political manipulation [24]. As the interactivity of IoT devices merges with or disappears within our everyday life and environments, we can witness an unawareness of users and subsequently users' loss of control and power. In terms of the design of IoT systems and devices, several scholars [15,16,30] mention the neglect of users' input and engagement in IoT developments. Desjardins et al. [16] further argues that while IoT aims to connect things with things by design it lacks the taking into account of the relations between IoT things and their lived-in environments, which include existing computational and non-computational things or systems. Crabtree et al. [13] propose building accountability into IoT models through specific HCI-oriented policies and procedures to better handle privacy issues.

Our view of IoT builds on the idea that IoT things will find themselves in the midst of complex configurations of human and non-human interactions or what we have elsewhere referred to as intersections and ensembles [33,46]. There is an inherent lack of stability and sharing of agency with non-human factors that as a consequence challenge the prescriptive reduction of things to functions and services all the while controlling human concerns like privacy and security. We therefore argue that there is a limit to the dominant human-centered perspective and that a better understanding of the nature of connected things would arise from a better understanding of the complex and ambiguous relations between things and humans.

Philosophies of technology

In many respects, our approach in Morse Things aligns with a particular strand in philosophies of technology known as postphenomenology. Briefly, postphenomenology as argued by Don Ihde and Peter-Paul Verbeek [26,43], understands technologies as mediators of human experiences and practices rather than functional and instrumental objects [39,43]. In a postphenomenological relationship between humans and technological artifacts, each mutually shapes the other through mediations that form the human subjectivity and objectivity of any given situation. Design is central to and bound up in a postphenomenological understanding of the world since digital technologies do not come to us in a "raw" form but in a form that is *designed*. In this respect, designed digital artifacts, or in our case *things,* manifest technologies and directly influence the mediation of our experiences and practices. Beyond postphenomenology, recent philosophical thinking like object-oriented philosophy [22] has adopted more radical thing-centered approaches that advance the position that things and artifacts bare knowledge in distinct and complex ways. While there are important differences in their own epistemological commitments, emerging theoretical notions such as Ian Bogost's *carpentry*, the construction of artifacts that do philosophy [8], Graham Harman's speculative realism that critiques anthropocentrism and the undermining of objects in philosophy [22], and Davis Baird's *thing knowledge* in which artifacts embody and carry knowledge prior to our ability to theorize or reason through language [5]—all offer intriguing perspectives that can be seen both as critical and generative mechanisms for thing-centered approaches to design.

Drawing on the philosophies and philosophers of technology such as Ihde, Verbeek, Albert Borgmann, and Bruno Latour [9,25,29,43,44] is not new to HCI research (see for example [17]). Recent research like Odom et al. [32] describe attachment as a key factor in human-technology relations for future design implementations. Pierce and Paulos [35–37] aim to describe the materializing of technologies and its implications from the material awareness of everyday things to embodied relations within technologies. Relatedly, Tromp et al. [42], reflect on the social consequences of mediated relations and argue that designers should make more informed decisions to design for socially responsible behavior. Our investigation similarly focuses on the role of the thing yet moves beyond materials, embodied interaction or moralizing behaviors to articulate the complex and ambiguous relationships that form between things and us.

Thing perspectives in HCI

Drawing on the philosophies of technology and object-oriented philosophy we can see that the notion of a *thing* is neither in reference to technologies nor simply artifacts in

the physical sense. Things can be seen as non-human technological entities and artifact entities often bound together that are conditioned by humans and in turn shape what it means to be human. As such, they have a central importance to HCI as computational artifacts, systems, and processes that can be referred to as things.

Crabtree & Tolmie [13] explore a "day in the life" of things through analysing a series of mundane interactions within a household. It is an investigation of the challenges to the design of IoT things. This ethnomethodological study portrays a perspective of things in order to uncover the underlying "machinery" of interactions that tends to fade into the background yet governs the meaning of things in our everyday lives. This research provides a thorough but explicitly human view of things from third-person human perspectives.

Related research has taken more literal approaches to the notion of a thing-perspective. For example, the PetCam [28] BinCam [12] and FridgeCam [19] utilize small cameras embedded or attached to objects (and pets) to provide a visual perspective that is quite literally from the perspective of things. On the surface, these approaches appear to provide viewpoints unfamiliar to humans and in this light they reveal new insights and observations. For example, Giaccardi et al. [21] explicitly introduce things as co-ethnographers in a study that attaches cameras to household items like a kettle and cups to log a visual perspective on human actions and routines from the vantage point of artifacts. The Long Living Chair [38] by contrast does not set-out to observe human actions rather it embodies the relation to humans by detailing the day it was manufactured (i.e. its human age) and records and displays how many times it has been used. In contrast to our approach, these works adopt a thing-centered perspective of things that are in essence human-centered. The purpose and role of the things are purely focused on human actions and interactions whether to observe people or to embody and record human interactions.

Trojan Boxes [14] utilizes embedded cameras but turns its view to the lived experience of things that are mostly non-human encounters and show a world most people have not experienced. The Trojan boxes are mail parcels with a tilt-triggered camera inside to document the various stages in our global delivery system of goods. This work is similar to our approach in that it seeks to explore an existence of things independent of direct human action yet unlike our work and similar to others it relies on visual sensing as its main modality, a modality more common to humans than things. With the Morse Things, we instead intended to materialize the thing perspective of being on a network that manifests more broadly across perceptual modalities whether human or thing-based.

Summary

In contrast to the various approaches to IoT discussed in this section, our approach specifically builds on the idea that IoT things will become part of complex and contradictory configurations of human and non-human interactions. Further, we believe a thing-centered approach can complement the limits of human-centered approaches of IoT. We also build on postphenomenology in our investigation to focus on the role of the thing yet our emphasis is not on materiality, embodied interaction or moralizing behaviors but the ambiguous attachments that form and the emergence of new considerations for IoT that might result. As a matter of researching things we shy away from a thing perspective of human actions and routines and aim our observations and insights back onto the things themselves.

THE MORSE THINGS

The Morse Things are sets of ceramic bowls and cups that communicate solely to each other over an Internet connection. Over time, the conversation of the Morse Things and their degree of connectedness on the network can evolve in degrees of "awareness" from being alone, to being a pair of things, to being a group of things, to being part of a larger network of things. The Morse Things mostly sleep (computationally speaking) and wake at random intervals during the day at least once every eight hours. Upon waking a Morse Thing will send and receive messages to and from other Morse Things in its set. The messages sent by each Morse Thing are in Morse code and simultaneously expressed sonically and broadcasted on Twitter (Figure 2). The Morse Things can be used like any other bowl or cup for eating, drinking, and containing items, with the exception that they cannot be put in the dishwasher or microwave. We designed and fabricated six sets of Morse Things each including a large ceramic bowl, a medium bowl, and a cup. The form of each Morse Thing is made of ceramics that is shaped around the embedded electronics signaling the design intention to create a hybrid between an everyday and computational object.

Each Morse Thing is comprised of a Wi-Fi microcontroller, sleeping module, amplifier circuit, speakers and battery. When a Morse Thing wakes, it checks an Internet server for messages from other Morse Things in its set. The Internet server coordinates the messages sent and received by the Morse Things. Each Morse Thing has its own name based on its color (red, yellow or blue) and set. Each set has a unique name and color combination of bowls and cups. The

Figure 2 Excerpt of a conversation of one of the Morse Things sets on Twitter

Morse code we used is a combination of traditional and adapted Morse abbreviations. Next, we turn to giving insight into the many decisions in the process of crafting the Morse Things.

Designing the Morse Things, we adopted a material speculation approach to design research. Material speculation is the design of a counterfactual artifact that is experienced and lived with on an everyday basis over time as a way to ask certain types of research questions [47]. A counterfactual artifact is a realized functioning product or system that intentionally contradicts what would normally be considered logical to create given the norms of design and design products. Morse Things are counterfactual IoT artifacts for the home in that their digital capabilities are at the service of things rather than people. Their human functionality is of an everyday nature that already exists in homes today shifting the question from what they *do* to how they *are* in our homes. The Morse Things embody the proposition that our relationships with Internet enabled things is a matter of negotiation over time rather than predefined or prescribed as a service or functionality.

We chose to design ceramic bowls and cups because we wanted our Morse Things to readily fit with and be accepted like any other household object in order to perform the inquiry of a material speculation. The combination of technological and non-technological identities within the Morse Things underscored our use of *defamiliarization* as a technique common to speculative design (see for example [7]). To defamiliarize is to make the familiar strange as a way to call into question the usual interpretations of everyday or known things.[1]

We purposely limited the communications of the Morse Things to communicating with each other and to affirming their individual or group existences on a network. The aim here was to foreground a thing-centered approach. In a sense, we designed the Morse Things to ask the question what is it like to be a thing on a network? We exaggerated the thing-centered approach by designing computational technological functions of the Morse Things to the exclusion of people, to have the objects computationally exist in their own world independent of human action. While they can be used as any other bowl or cup for eating, drinking and containing items, this use does not impact their communication or "awareness" nor are these interactions with the Morse Things sensed or data logged. We constrained the computational technologies to be solely at the service of the Morse Things. These strategies are

combined as a way to both acknowledge and inquire upon the gap between things and us.

Enforcing the gap between technological things and us was important however it was equally important to design links and reminders of the potential relations between the things and us despite this gap. The physical form of the Morse Things was aimed to keep present the idea that the bowls and cups were also technological objects although the electronics were hidden. The form of the bowls and cups protrude in odd shapes (unlike other ceramic bowls) revealing where the electronics fit between inner and outer ceramic shells (Figure 1). Similarly, we chose to make the communication between the Morse Things potentially intelligible to people yet still thing-centered by having them in Morse code, sonically expressing the messages, and translating the messages on Twitter. We chose Morse code as both potentially familiar yet an outmoded form of communication that is for human communication yet designed for the mechanical and electronic properties of non-human things. Twitter was chosen as the Morse Things' communication platform because it was easily integrated into our system, enabled participants to monitor the communications easily, and is reminiscent of other IoT things on Twitter (see for example @mytoaster [50]).

OUR STUDY

With the main goal of exploring a deeper understanding of the gap between things and humans we applied a relatively unique methodological approach. Our study adopts a material speculation approach as discussed earlier (see The Morse Things). In material speculation the first step is the design and making of a counterfactual artifact(s) that embodies a proposition and research question, and is robust enough to be deployed in everyday settings for long periods of time. In the second step of deploying the counterfactual artifacts we adopted a unique approach to deployment studies that is in keeping with the particularities and challenges of the research questions we are asking. A key motivation in our approach was the desire to deepen our

Figure 3 Participant photos of Morse Things in their homes

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[1] Defamiliarization is originally a literary theory device (see [41] to have readers examine their assumed interpretations of known and familiar experiences. The literary critic, Frederic Jameson cited in Bleeker [7] succinctly characterizes the aim "defamiliarize and restructure our experience of our own present…" [27]. Bleeker is one account of utilizing defamiliarization in design fictions and others have argued for it as a critical inquiry approach within HCI and domestic contexts in particular (see [6]).

investigation by including a wider range of experts that have the design expertise to perceive and investigate the nuanced and challenging notions of thing-centeredness. In order to do so, we set out to sensitize–through lived experience–a group of *domain expert participants* [18] to our thing-centered approach by deploying the Morse Things in their households for several weeks. In the context of this study, we see this deployment as a priming exercise. Data from the lived-with experiences with the Morse Things was collected (Figure 3) however our main interest was to engage in a workshop with our expert participants to discuss the relationship between things and us after they had the lived experience of the Morse Things. In what follows, we describe the individual steps of our methodological approach focusing on the deployment and workshop given that the methods of material speculation have been previously published in detail [47].

Deployment

We deployed the Morse Things for six weeks with six domain expert participants who were engaged in interaction design professional practice and research. After the novelty period of about one week the Morse Things eventually became part of the daily lives of the household. All expert participants lived with other household members and in what follows we describe in detail the households beginning with our primary participants and mentioning who participated from the households in the workshop. All participants are given pseudonyms:

Olivia (30) holds a PhD in interaction design (IxD) research and a bachelor's degree in industrial design. She is a professor in Interaction Design at a university in a nearby city. Her partner Noah (32) holds a degree in landscape architecture and has been working in landscape architecture for over eight years. Both participated in the workshop.

Ethan (47) holds a PhD in media arts, has several years of experience in research and art practice and currently holds a chair position as an art and design research faculty member at another local university. His wife Emily (32) is an experienced social science researcher and media professional holding degrees in anthropology and cinematic arts. The also have a 4-year old son Edwin. All three household members attended the workshop.

Hannah (31) is a senior Experience Designer and Digital Strategist with over six years of work experience at leading design agencies and consultancies in North America. She holds an undergraduate degree in interaction design. She participated in the workshop.

Ella (47) is a senior design faculty member, with years of design experience, and a special interest in textiles and wearables. She holds a bachelor's and master's degrees in design. Her husband Mike (53) is a scientist operating in the field of endocrinology and molecular biology. They have two children, Heather (20) a third-year communication design student, and Tim (18) a professional water polo

Figure 4 The Morse Things as they were delivered to the participants.

player. Only Hannah participated in the workshop but shared some of her entire family's experiences.

Spencer (37) is a practicing interaction designer specializing in the production of interactive installations and creative applications with over 10 years of work experience and his own company. He holds an undergraduate degree in interaction design and a master's degree in Interface Culture. His wife Mel (35), who is an independent art curator and art history PhD candidate, and their 2-year old (Marvin) did not participate in the workshop.

Toby (34) is a senior interaction designer with 10 years of work experience and his own company in the field. He holds an undergraduate degree in interaction design. His partner Sandra (30) works as a library assistant. She holds an undergraduate degree in photography and has some work experience in the telecommunication industry. Only Toby attended the workshop.

As we mentioned earlier, we see the deployment of the Morse Things as a priming method for the workshop that followed. Through the deployment we aimed to spur our participants' engagement with the Morse Things. For each household, we provided a set of Morse Things (each included a large bowl, medium bowl, and cup plus a Wifi hub and a set of instructions) encased in a wooden box (Figure 4). The box also contained an information sheet specifying the messages that Morse Things send, how they translate, and when they occur and how to access the messages on Twitter. Participants were asked to live with the Morse Things and to document the experience in response to a question and task we provided: *Describe what it is like to live with the Morse Things from the perspective of the Morse Things*? And *Design an artifact, system, or service to co-exist with the Morse Things.* It was left up to the participants as to the form of their response and the form of the concepts they generated. While living with the Morse Things our participants gathered photos, video, and text entries from diaries, as well as sketches of concepts. Across all participants we gathered 233 photos, approximately 30 minutes of video, 34 days of diary entries, and 18-20 sketches of concepts. For the purpose of this study, this rich data is part of the priming of our participants, however, it still informed workshop activities

and discussions. We aim to analyze this deployment data to a larger extent in future research.

Workshop

At the end of the deployment, we organized a workshop with all of the domain expert participants and family members with our own team of three researchers to discuss the role of the Morse Things and ultimately the idea of the gap between things and humans. During the workshop, which lasted approximately six hours, the expert participants were asked to first present individually their experiences of living with the Morse Things and give special attention to the deployment question about the experience of the Morse Things from the perspective of the things. In a second round of presentations, participants presented their individual concepts of things designed for the Morse Things. Then, participants were divided into two groups and engaged in a group activity of designing things for the Morse Things as a group. Throughout these workshop activities we engaged in in-depth discussions with our domain expert participants that was as lively as it was informative. We gathered audio and video recordings of the workshop.

DATA ANALYSIS

After conducting the deployment and the workshop, we set out to analyze the collected data. The data included: text, images and videos collected from participants during the deployment and workshop data including presentations given in response to our deployment activities (see Deployment) and design concepts generated during the workshops; and lastly our videos and audio transcriptions from the workshop. Our method for analyzing data was done collaboratively by us, the researchers. Data was analyzed into themes through grounded theory techniques of open, axial and selective coding [11].

FINDINGS

In analyzing the data from the deployments and workshop we found three main themes: 1) searching for humanness; 2) thing-centeredness; and 3) tensions in making sense of the gap between things and us. Our analysis is organized to reflect the shift in thinking of our participants from viewing things as human-related to then thing-related and lastly the tension of holding these two positions simultaneously.

Searching for humanness

Projecting human qualities onto the Morse Things

Participants projected human emotions and experiences on the Morse Things. For example, Hannah translated the messages of the Morse Things into more human language. She also considered the "emotional life" of Morse Things like feeling lonely, frustrated, bored, forgetful, restless and ignored. Olivia described the reactions of the Morse Things to events in their 'lives'. For example, she thought the Morse Things would be happy with their new home, and as the Morse Things made sounds when she and Noah entered the house, she imagined them to be happy to see them: *"they were here and they spoke a little bit and then we went*

out for dinner […] we came back […] and as we entered the door, someone, one of them was like bipbipbip, and I was like, Oh! He's so happy to see us!"

Comparing Morse Things to family members and pets

Along the same line of analysis, the Morse Things were compared to humans and animals. For example, Olivia described the Morse Things as a family that stayed together as a set. The Morse Things were compared to children in different instances. Noah described them as young children that were learning and evolving. In their presentation during the workshop, Ethan and Emily emphasized that their son Edwin could most easily relate to the Morse Things because "*he is already in that space, making Lego and doing things."* Most of Spencer's concepts were inspired by children's toys motivated by a desire to maintain the abstract and playful aspects of the Morse Things. Both Ella and Emily compared the Morse Things to teenagers, as well as to cats thinking of them as going their own way: "*I think what they do is make us aware that there's other things going on that we have no idea about, like with the teenagers. […]. I don't know what the cat is doing when I'm sleeping or what my kids are doing."*

Morse Things being aware of humans

In responding to our request to document the experiences of the Morse Things from the perspective of the things, the Morse Things are described as thinking of and being aware of the people in the house. Spencer describes conversations between the bowls and their thoughts of humans, which in his account they call 'strange giants': *"I get used the most in the morning. But, not the way I expect. The big one usually puts some sugar and milk in me before the warm brown liquid. Which is strange, because it does it the other way with those stupid mugs."*

Ella also describes, in a short-sentenced robotic way, the Morse Things' awareness of the people in the house: *"Human number four only heard us once…; Human number two has been waiting for a …; Human number one is remaining objective. ; Human number three can't count our attempts to connect. "*

Control and feedback modalities for humans

In their concepts, participants indicated a desire to better connect with the Morse Things. For example, when the

Figure 5 Hannah's concept of Morse Things as part of daily routines.

Morse Things would make a sound, Spencer tried to keep track of which Morse Thing was saying what, but always found himself too late to distinguish and locate the sound: *"Maybe an LED in the rim or something, which got brighter every time there was some activity, and then faded out over time to give you some indication of how active they had been relative to each other."* Participants' concepts also included giving the cups and bowls personalities which could reflect in the aesthetics of interaction, for example sound and light. Hannah was specifically looking for added feedback modalities motivated from a more empathetic standpoint in which she mainly wanted to make sure the communicating cups and bowls were finding each other: *"I thought that if one was seeking, another could vibrate".* This empathy with the perceived struggle of the Morse Things connecting to each other was also reflected in the concept of another participant who envisioned a device that would manage the timing of their messages, enabling the Morse Things to be "awake" and communicating at the same time.

Connecting to human practices

The desire to connect the Morse Things to human practices emerged too: *"If they could detect us through motion, or maybe just by touch, if we pick them up and all of a sudden they vibrate or they spoke or they can feel us touching them."* Beyond direct interaction, participants were envisioning ways in which the Morse Things could work themselves into daily human routines (Figure 5). Ethan's concept positioned the Morse Things as use-logs that would remind you of your last activity with them 24 hours later, to recall or even dictate routines, where Hannah's concept argued for having the Morse things as melodic, harmonious companions providing moments of reflection in everyday mundane things: *"They would wake up with us, as we are starting our day. So if I walk past a cup, and maybe a coffee maker, it would just chime as I walk by it, and as I do more it becomes a bit more musical."*

Thing-centeredness

Learning the Morse Things' language

While the Morse Things were often approached from a human centered perspective, on many occasions a more thing-oriented projection came through. Participants felt like they themselves needed to learn more about being a thing to understand the Morse Things. Noah mentioned that it might take more time to understand the Morse Things: *"Maybe it's a process that takes a longer time to really see. Because, like everything takes time to evolve and change, and maybe the speed of that discussion is like that. Maybe not a computer speed evolution, more like a human evolution. More slow basically, versus technology going really fast."*

Noah and Olivia also talked about learning Morse code to understand the Morse Things' conversation. Sandra, Toby's partner, wanted to tell them apart: *"I continue to keep trying to grab the bowls while they are "tweeting." I don't know*

why I'm doing this, because I can just wait and check Twitter to see which bowl it was ... guess I feel like I might be able to learn if they have different sounds? Maybe I'll be able to tell them apart eventually."

Things with other things

In our expert participants' concepts, the Morse Things were often connected to other objects in their environment. Concepts included the Morse Things as eavesdropping bowls that listen in to you and your devices, and the Morse Things as silent ethnographers informing a social tablecloth that keeps track of the activity in a coffee shop. Other concepts looked at possibilities of how the Morse Things could include other things in the house on their network, for example Olivia proposed the idea that the Morse Things could "hack" into other things in the home like televisions to join their network (Figure 6).

Comparing to other things and new type of thing

In understanding the Morse Things, expert participants compared and related them to other existing things. Ella compared them to lost socks: *"I was also thinking that the home that you live in sort of contains these lost things. It contains a lot of lost socks, they are somewhere. The bowls are in the same way sort of contained."* (Figure 7) She continued this comparison in explaining why the bowls were useful and useless to her at the same time: *"[...] those are things that are in our homes and they are just, they're there. I suppose that's why I went to that space because although we think of bowls functioning in a particular way, we put things in it, as another type of entity that has a digital life, it wasn't functional. It was like the lost socks. We have an object that actually functions, physically, but we have an object that is just there. So you are playing with our assumptions."*

Noah did not see the Morse Things as different than other cups and bowls, and compared them to the Nest thermostat: *"To me, there's technology in it, but I look at it as a thermostat. I don't see it as being a new everyday complex thing. I look at that thing and I look at the Nest thing, and it's the same thing for me. So the same with the bowl, I look at that bowl and I look at the other bowl in the cupboard: same thing."* He also compares the Morse Things' conversation to playing a Compact Disc (CD) or running a script on which he has no impact: *"It feels like it's a CD that plays on a loop. It plays that and it just keeps going."*

Figure 6 Olivia imagined the Morse Things could hack into other things to join their network

Figure 7 Ella's concept for finding and containing things

Toby introduces the idea of the Morse Things being a new class of object and positions them between a digital product and a puzzle or a painting: *"It's kind of a new class of object. I was thinking is there any non-digital object in my house that is actively disrupting the environment for its own pleasure, [...] just to please itself. And there isn't really. Sometimes you'll have like a puzzle or an object you misread, like maybe you got a painting and you still haven't really figured out what it is, what it means. But that's different, because it's passively there, and you choose when to engage with it and you get to make some meaning. You're not really trying to put it to any purpose, whereas the bowl...sometimes you are trying to put it to purpose and than it just interrupts you and is like hey, figure me out."*

Tensions in making sense of the gap between things and us

The tensions in making sense of what the Morse Things were and what role they could play in everyday life was very present throughout the study. While Olivia "*loved imagining*" that the Morse Things talked and cared for her and her partner, she realized that "*that's not what they're saying at all, and they don't care about us at all*". Emily described a situation in which she was not home, but saw on Twitter that the bowls had been making sounds. She continued with her comparison to cats and teenagers: *"And there is something kind of nice about not knowing, [...] but with a bowl, that's where it sort of gets strange."* Ella recognized this friction, and attributed it to the fact that the bowls are not conscious beings: *"If my kids are going out and they have a relation and they are talking with each other – I don't know what's going on but I know they're doing it – I at least know that they are conscious and aware of it. With these bowls I know that they are not. That's why it seems like [...] why are we doing that for them if they are not conscious or something going on."*

Continuing with his comparison of the Morse Things to a CD or script, Noah wondered whether the experience of the Morse Things is actually ours or the designer or researchers who made and programmed them. This friction in what the Morse Things are or should be continued in participants' concepts. Where some participants' concepts added explicit functionality to the Morse Things, for example Toby's

concept of them as part of a system in which they would function as both a WiFi repeater and a plant watering reminder system (Figure 8), while Spencer was very clear in his desire to avoid making it useful, as he wanted to keep thinking of them as an abstract, playful thing, rather than something utilitarian. Hannah mentioned that she did not need the Morse Things to have more functions: *"It doesn't need to have a specific use, I like that they are just there and kind of in their own world and speaking in their own language, and sometimes my interactions with them impact them."*

Should things exist for us?

In the discussion at the end of the workshop, the participants were divided in their opinions on whether the Morse Things should exist for us, as Ella argued *"if it can talk, allow it to talk to us. If it's communicating than we want to have a conversation",* or whether they should exist on their own as Spencer says *"that's why I like the idea of something else, let them be themselves. Other stuff is going on that we're just totally unaware of and it doesn't matter."*

DISCUSSION

The discussion that follows represents an answer to the question we posed at the outset of our paper: what might be revealed in the relations we have with technology through a thing-centered approach to IoT? Aspects of the answer include the withdrawal of things from our human understanding and perception that contributes to the gap between things and us, the ability to form attachments with things despite this gap, and lastly the notion of a new type of thing between thing-centered and human-centered technologies in the home.

These insights contribute to our discussion of human-technology relations in the context of IoT (See Background). Specifically we extend related IoT research that raises issues of human and non-human agency alongside a shift away from human-centered concerns [15,16,30,47]. Our insights reflect and engage through design, the thing-centered philosophical inquiries of post-phenomenology Ihde and Verbeek [26,43] and object-oriented approaches of Harman [22] and Bogost [8].
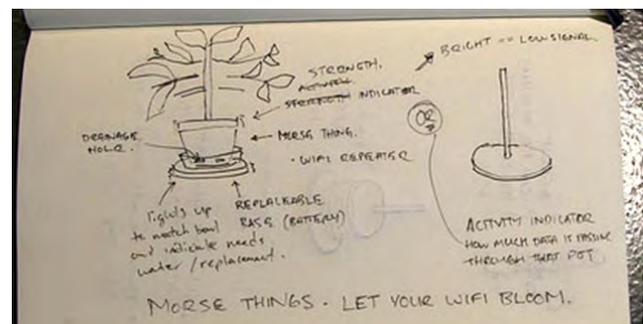

Figure 8 Spencers concept of having the Morse Things as a WiFi repeater and watering system

Withdrawal of things from human understanding

Understanding experience from the perspective of things is a difficult task for humans. We tend to relate to non-humans as surrogate humans, that is we anthropomorphize non-humans. Philosophically speaking, non-human perspectives "withdraw" from human understanding into a non-human world that we can neither fully comprehend nor articulate [8,43]. In addition, non-human worlds are formed in a configuration of materials and performances rather than language [5]. This naturally poses inherent difficulties in adopting thing-centered perspectives.

This challenge was confirmed in our study as our domain expert participants readily described the Morse Things as having human qualities like an "emotional life" (Hannah) or belonging to a family (Olivia). In imagining the perspective of the Morse Things, participants gave them language and forms of agency. For example, Spencer saw the Morse Things as human-like characters that perceived humans as 'strange giants'. Ella described the Morse Things similar to how one might describe robots that express themselves like humans but through logic and without emotions.

It is important though that these interpretations were not resolute and our participants knowingly held contradictory views of the Morse Things. These knowing contradictions acknowledge the gap between what we imagine of things and how they actually exist. Referring again to comments made by Olivia (see Tensions in making sense of the gap between things and us), she said that despite the fact that she "loved imagining" that the Morse Things talked and cared about her she knew they did not care at all about her.

Our study gave details on experiencing the gap between things and us but also revealed the more nuanced idea of how things withdraw from our understanding, as has been expressed by [8,43] and others. It is important that while much of the experience of things is beyond our grasp, this perspective is not entirely invisible to us. Rather we establish many commonalities and reliable interactions that form the foundations for the fundamental and ubiquitous relations we have with things. This relationship to things in the context of their withdrawal emerged clearly in our study. For example, we reported on how Ethan and Emily believed Edwin, their 4-year old son could best relate to the Morse Things since he spent his day playing in an imaginary world of things. Ella and Emily throughout our workshop compared the Morse Things to pets and teenagers signaling familiar relationships that at times are very unfamiliar if not inaccessible to us.

Attachment with things we don't understand

Despite this gap between things and us it was evident in our study that participants formed attachments with the Morse Things. After the initial curiosity subsided the Morse Things were momentarily forgotten or ignored but later became part of the daily lives of the homes. This was clear in the reports and images sent to us during the deployment (see Deployment). In addition, the Morse Things' messages were routinely checked on Twitter and participants spoke about taking care of their set. In one incident, two sets were accidentally swapped during a maintenance check and both households immediately demanded their own set back (each set is a unique combination of colors). Lastly, at the end of the deployment, nearly all participants wanted to keep the Morse Things. This attachment with the Morse Things was not necessarily a foregrounded experience but rather one in which the Morse Things faded into the background of everyday living to on occasion surface in ways that caused reflection, new considerations and even pleasure and comfort. Toby's comment on his experience of "rediscovering" a Morse Thing speaks well to a type of attachment that was common in the study: *"finally heard a bowl! It's been a week. I didn't expect that I would be as surprised or excited as I ended up being. Had a pretty good rhythm to it. Dah-do-dah-do-do-dah-dah-do-dah-dah ... or something like that."*

The attachment to the Morse Things was also described in ways that acknowledged that the relationship was with things that could not be fully understood–that the relationship could be more thing-centered than human-centered. Noah commented on how it may take time to fully develop a relationship with things that in the case of the Morse Things would be at a slow evolutionary speed rather than computer speed observing the difference between things, humans, and computers. Noah and Olivia also discussed learning Morse code to better to understand the Morse Things from their perspective. Lastly, Ella elaborated that the attachment was a matter of things that function on some level (being a bowl) but digitally they are "just there" in our home.

A new type of thing in the home

We propose that the Morse Things can be viewed as a new type of thing in the home that is neither a human-centered nor thing-centered. The Morse Things are not typical everyday artifacts like other bowls or cups in the home but you can just as easily use them like a typical bowl or cup. They are also not digital devices like mobile phones or smart thermostats, however they are Internet enabled and connected.

Toby was explicit and most insightful about the possibility of a new type of thing. He considered Morse Things to be a "new class of object" that he compared to artifacts like a painting. One does not fully understand a painting yet one forms a special relationship that spurs ongoing reflections and interpretations despite knowing these can never be resolved. However, unlike paintings, Morse Things have autonomy and "interrupt" or emerge into our lives on their own accord. This is the crux of the new type of artifact, one that we are ambiguously attached to in our daily life and is in many respects independent of our actions and desires. This notion of a new type of thing opens IoT approaches to consider IoT things that form attachments with people through qualities other than human driven functionality or

explicit services. Ambiguity in this sense is a resource [20] that adds dimensionality and complexity that is more commensurate with human-technology relations; Verbeek reminds us that technologies are mediators of human experience and practices rather than functional and instrumental objects [43].

Ambiguity or ambivalence in relation to this new type of thing is important to recognize. In keeping with the complexity of our relations to things it is not clear why these relations should be resolved or satisfying in order to maintain an attachment. Maintaining relations while not knowing is critical to future possibilities and alternate meanings that ultimately sustain our relationships with things. In our study, this ambivalence with the attachment to Morse Things emerged. Ella, in her comparison of the Morse Things with teenagers makes the point that they are "conscious and aware" as opposed to the Morse Things that "are not conscious" and yet we are concerned for them in ways similar to our complex relationships with teenagers.

In existing IoT systems we see glimpses of non-human agency and thing-centeredness in systems that automate updates of mobile operating systems and applications or service and maintenance notifications of appliances and automobiles. However, these are human-centered in their orientation, focused on automating human tasks. An overlooked example but one that is more relevant may be the accidental relationships that form between digital things and other things. For example, audio speakers that unintentionally convert nearby cellular radio transmissions of mobile phones into sound that can reveal incoming data or phone calls. This unintentional thing-to-thing interaction reveals independent but intelligible thing-centered interactions. In other research we have discussed the idea of *ensembles* [33,46] in which over time things configure into relations *seemingly* on their own. Examples of this include complex arrangement of objects and furniture in your apartment or home, or how keys always find themselves in a bowl on a table near the front door. Human actions co-mingle with non-human qualities to form ensembles that demonstrate the thing-centered relations that would be typical of the new type of thing our Morse Things suggest.

CALL FOR FUTURE RESEARCH
Morse Things may manifest a new type of thing in the home despite the fact that they are not intended as a viable or commercial product. Morse Things are a counterfactual artifact produced to perform a research inquiry into new IoT possibilities [34,47]. They disclose alternatives that set the stage for further research and development of a thing-centered IoT.

In support of pursuing a thing-centered IoT research agenda, we also see the need for methodological innovations. For the Morse Things we decided to pursue a different methodological approach that asked domain experts to be study participants that co-speculated with us in our inquiry. Furthermore, we relied on generative activities

that infused each step of our method that together with our expert participants navigated this new space of thing-centeredness. Giaccardi et al. [21] invokes things as co-ethnographers, Pschetz and Banks [38] embody human relations into crafted artifacts, and Davoli and Redstrom [14] engage in thing *sousveillance* as methods to thing-centered understandings. If we look to enable designers to design a new type of thing for the home that is situated between human-centered and thing-centered orientations, new vocabularies, practices, and methods are required. As a matter of including philosophical work into design, new concepts and language will need to be worked through and become manifest in both design processes and artifacts. This is in the spirit of Bogost's *carpentry* in which through the making of things we do philosophy [8].

This work leads us to invite researchers to contribute to a thing-centered IoT and interaction design research agenda. We also invite further future work in tackling methodological issues better suited to investigate human-technology relations and thing-centered approaches.

CONCLUSION
In this paper, we presented our design inquiry into the gap between things and us in our Morse Things project. We employed a material speculation approach to this investigation that led to the design of counterfactual artifacts in the form of ceramic bowls and cups as IoT things networked together and independently communicating through Morse code. We described our deployment of the Morse Things in the households of six interaction design practitioners and researchers for six weeks as domain expert participants. We analyzed the data gathered from our deployment and a workshop to reflect deeply on the nature of living with IoT things and discuss insights into the gap between humans and things. Our findings and discussion led to the idea of a new type of thing in the home that is neither human-centered technology nor non-digital artifacts. Lastly, we suggest future research to pursue things that are between human and thing-centered considerations and the need for new methodological experimentation for both thing-centered and human-technology relations related to design research.

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