An Internet of Social Things

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ABSTRACT
The Internet of Things is a vision for a world of interconnected smart devices. We present an alternative vision based on a review of literature that emphasizes the importance and role of objects in social relations. We situate this work in relation to a conceptual understanding of objects and sociality, and note some methodological implications of a more object-centred sociality that may suggest design opportunities alongside the emerging Internet of Things.

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INTRODUCTION
As computational technologies continue to 'disappear' and merge with the physical world, becoming increasingly tangible, embedded and embodied in a range of environments, architectures and artifacts, new research agendas and design approaches are called for. One increasingly relevant issue in this context is how we understand and work with the everyday physical objects around us when any and all of them can conceivably become digitally augmented. The growing possibilities for augmenting physical objects with computing capacities has implications for our relationships with a range of things and suggests opportunities for design researchers to reconsider the particular and situated ways various everyday objects materially inhabit and socially share our lives. In this paper we propose a conceptual and methodological consideration of 'an internet of *social* things' to address this concern.

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Objects instrumented with computing technologies, sensors, networked protocols and so on are, within the vision of the Internet of Things (IoT), viewed as physical entities that can be interconnected and made smarter, exchanging data and information with other objects.. Yet, physical objects also have a social existence that we suggest can be supported through the IoT. We use the term an *internet of social things* to emphasize this importance and role of objects in social relations. In one sense, objects are social through the role that they play in mediating human social relationships. In another sense, objects have a social life of their own through the fact of their emergence, persistence, relations and death. This is not to suggest that objects are equivalent to, independent from, or sentient like humans, but to recognize that they do have an existence and agency that might be supported through IoT designs. In a third sense, then, designing IoT technologies to support the social aspects of objects so that they interact *with each other* situates objects as 'users' of technology.

There is a tradition of challenging the term 'user' in HCI, particularly for its homogenizing force, which standardizes, instrumentalizes, or reduces the cultural contexts and complexities of human interaction (e.g. Brereton, 2009). The implication is the system is at the centre of concerns, with the human merely supplying its informational needs. In this vein, and as a productive design provocation, we aim to broaden the constituency of those that might be counted as users in order to extend social agency to objects. This provocation, taking a view that holds the object and its relations as central is productive for thinking about how we might recast our understanding of the IoT. Again, understanding objects as social agents and 'users' of technology is not to attempting to equate them with humans or grant them some kind of autonomy, but to recognize they have specific properties, histories, affordances, and relations, which might be augmented through the IoT. It is important to note that objects are part of socio-material networks that impact on human relations -- without humans in their networks, their impact is inconsequential, at least to us humans.

Drawing on what has been described as a 'material turn' within the humanities and social sciences, and more recently within HCI (Robles and Wiberg, 2010), this paper proposes attention to the "internet of social things". These

things – everyday physical artifacts populating our world – are understood as active mediators of social relationships, which might be between people, computational devices or other objects.

The paper's contribution is threefold. Firstly, we provide a brief overview of the Internet of Things, and of several projects that use RFID to gather, enhance and mediate the social meanings that everyday objects hold for their users. We discuss and reinterpret research that is concerned with the social life of things and we bring together different strands of research, which we feel speak to the concerns of objects as social actors. Secondly, we consider the design challenges that follow from an understanding of 'social objects'. We present a conception of social objects as users of computing technologies.

Finally, we argue for a methodological approach that follows from an understanding of object sociality, for both object design and ethnographic research into the Internet of Things. We describe our relevant recent research and propose an object-oriented approach to ethnography as one methodological approach to studying the use of technologies by humans and artifacts alike.

THE THINGS OF THE INTERNET OF THINGS

The horizon of ubiquitous, pervasive and ambient computing suggests that information sensing, processing and networking will spread into the physical world and operate at multiple scales: from the body, to the building, to the street. Whilst this understanding of ubiquity addresses the geographic distribution of computation everywhere/everyware (Greenfield, 2006), it also implies possibilities for embedding computational capacities into the physical stuff of every-*thing*. Ubiquitous computing imagines augmenting everyday objects and embedding computing in everyday environments with technologies for sensing, monitoring, tracking, and actuating, whilst the more recent Internet of Things (IoT) is a vision for a world of more intimately entangled relations between digital and physical.

The IoT anticipates the ways objects will be interconnected through Internet protocols to create networks of smart objects sharing data (Ashton, 2009), allowing collections of physical objects to communicate and interact. From a commercial perspective, the IoT is primarily a set of methods and standards for tagging physical products in digital networks, so that they can be tracked through their manufacture, distribution, storage and purchase. Other applications in areas such as energy, health, or transport envisage the IoT as integral to more efficient or optimized systems for networked or remote monitoring, communication and management.

Yet, from a design perspective, IoT technologies such as RFID are being explored not just for tracking products through their life cycle or connecting devices to optimize systems but also for annotating objects with sensors to create new forms of tangible and social interaction (Barthel et al., 2013; Martinussen and Arnall, 2009). Annotating physical objects to reflect their history and relationships — ownership, use, meaning making, and so on — can be exploited to reflect the importance of physical objects to human social relations. Yet, many examples of IoT that add informational components to existing objects retain a human-centered notion of sociality. This paper aims to broaden this notion of sociality for the IoT.

Martinussen and Arnall (2009) note that RFID-enabled objects are increasingly part of everyday life through a wide range of new consumer products. They argue, however, that the potential to add RFID capabilities to existing objects has largely been overlooked. They call for IoT research to move "beyond an internet of stickers, credit cards and keyfobs" (Martinussen and Arnall, 2009, p. 349). Martinussen and Arnall go on to explore physical possibilities and limitations for retro- fitting everyday objects with RFID, including gluing chips to the objects' surfaces, stitching into fabric and embedding inside objects, depending upon the material properties of objects.

Martinussen and Arnall also make the important claim that designing with everyday objects should be guided by consideration for their material properties and affordances, and the existing associations that users have with them. Tagging the everyday objects that surround us and share our lives for material interaction demonstrates an understanding of the user that begins to broaden beyond people to include and consider physical objects and their particular properties. While Martinussen and Arnall explore RFID technologies to augment the physical properties of objects, they do not extend this to consider the social properties of objects, such as their biography, inhabitation, or relationships.

Materials and materiality

An emerging area of HCI research, characterized as a material turn' within interaction design, is building upon the tangibility and ubiquitous paradigms of embedded computation through the idea of material interaction (Rosner et al., 2012; Wiberg and Robles, 2010). The material turn within interaction design seeks to understand novel digital-physical compositions by exploring the relationship between computation and material characteristics such as clay, felt, or even ice. This is not merely to remind us that 'immaterial' computation takes 'material' form, but that the specific material properties of storage media (for example) shape our interactions with them, as well as their interactions with each other (Dourish and Mazmanian, 2013).

Wiberg (2014) provides a schema for a methodology based upon materiality, including two dialectical pairings: materials and wholeness, and details and texture. The first pairing best captures the tension we are trying to address here. The objects we interact with are often taken as a

whole, but it is frequently their material properties that allow or facilitate that interaction.

An example of this approach is the Icehotel X, built in 2008 in Copenhagen (Robles and Wiberg, 2010). This temporary hotel made from ice drew on interaction design to integrate digital displays into the physical ice architecture. Instead of simply installing large digital screens onto the ice, this project sought to integrate the luminous properties shared by digital screens and material ice, resulting in a re-working of displays so they emitted light rather than high-resolution images.

By exploring relationships between computation and material stuff in digital-physical compositions, the study of material interaction is sympathetic to the ways existing materials are active contributors rather than simply inert substances or resources for computation. In doing so, it begins to challenge the concept of the user within HCI. The concept of the user, which has underpinned much of the theoretical and methodological approaches within HCI research, has traditionally been confined to human users. Yet, it has been noted that the move towards computationally augmented and digitally networked materials blurs and challenges this understanding of who and what a user is (Fallman, 2011). Through the emerging IoT vision, everyday objects are in a sense 'users' of computing technologies. Certainly, material interaction demonstrates an understanding of the user that begins to broaden beyond people to include and consider physical materials and their particular properties. Nevertheless, much of this prior work focuses on the interplay between the material and computational properties of objects. In this paper we want to extend this approach by including consideration of the social properties of objects, such as how their social history, mobility or relationships might be supported through design.

There are some notable examples of design projects that retrofit everyday objects with RFID and barcode tagging in order to accommodate such social properties or interactions. One line of research has explored the memories and stories associated with objects by investigating the use of personal objects and souvenirs as tangible interfaces for evoking and remembering shared events (Mugellini et al., 2007).

Material artifacts demonstrate a capacity to remember and communicate their past through the physical wear that gives glimpses into their use and history. Yet, the current contexts of ubiquitous computing and the IoT offer opportunities for digitally augmenting these biographies with other types of data. We briefly consider two illustrative examples: Memodules and TOTeM.

Memodules

The Memodules project (Mugellini et al., 2007) augments personal objects such as holiday souvenirs with RFID so that when the physical object is placed on a surface and scanned an associated collection of digital images is displayed. Mugellini et al. (2007) argue that because souvenirs are connected to the memory of particular events they are ideal for assisting associative processes of remembering. We note the common etymology shared with 'memory' and 'memento'. Whilst the authors confine their discussion to the category of souvenirs, this project implies opportunities for augmenting a broader range of everyday objects. Further, whilst such augmented objects are only discussed as tangible cues for supporting people's memory recall, they suggest opportunities for augmenting objects not just to evoke human memories, but also to support and recognize that everyday objects have a history and biography in their own right, which is worth telling, storing and sharing.

Tales of Things

An exciting example of digitally augmenting everyday objects that helps to realize the sociality of objects through IoT capacities for collecting, storing and sharing the stories of their life and the history of their relationships is the Tales of Things and electronic Memory (TOTeM) project (Bartell et al., 2013). This project (www.talesofthings.com) explores opportunities for augmenting almost any physical object with their social biographies. QR codes and RFID tags act as unique identifiers linked to the Tales of Things database, which is accessible by web browser or mobile application. People are able to record, read and share using a range of media their personal stories and social interaction with objects.

The authors describe the TOTeM project as a "mix between a 'Facebook of things' and the 'antiques roadshow for the future', whereby scanning an object replays its past, its associations, its locations and the memories of its owners" (p. 322). The artifacts tagged in the database range from everyday objects (such as coffee mugs, clothes, photographs, artwork and furniture) to buildings, places and spaces.

So while this platform is based on people's personal memories or individual associations with an object, the participatory, collective, and public qualities of the user-generated design support the collective past, presence and participation of objects.

This project has a number of salient implications for the internet of social things, including the possibility for recording information about an object's history of exchange, ownership and use, and its meaning and kinship within particular lived spaces and relationships with both people and other objects. Providing information and narratives about an object's past may also enhance its social and economic value in ways that assist in prolonging its future, and so speak to concerns in sustainable design (Odom and Pierce, 2009).

In some sense the Tales of Things project creates a 'social media' version of the Internet of Things by supporting objects in establishing and maintaining social ties. But by

only instrumenting objects with tagging technologies, much of that interaction remains in a digital rather than physical environment. Opportunities to explore the objects' material and tangible characteristics and to understand how this contributes to a broader social ecosystem are limited. In the following section, we present an understanding of the sociality of objects that takes into account their material properties, relational affordances, and social biographies.

THE SOCIALITY OF OBJECTS

We have suggested that as IoT technologies enable devices to communicate with each other, the figure of the human 'user' needs to be complemented with an understanding of objects as users of computing technologies. In this section we present the concept of the 'social object', which grasps the relationships between humans, material artifacts, and their environments. We then present two examples that illustrate a more object-oriented understanding of social relations, which is not exclusively human.

The recognition of object sociality, where objects not only materialize relations between people but are also active participants in human social life (e.g. Knorr-Cetina, 1997; Latour, 2005), is established in a number of disciplines, including anthropology, cultural geography and science and technology studies. The notion of object sociality draws upon an expanded sense of agency, which is distributed between humans, animals, technological devices and physical artifacts. This conceptual approach suggests, then, that instead of approaching objects as discrete entities or through notions of instrumentality or commodity, we explore the ways they participate in collective life. Sherry Turkle, for example, describes "evocative objects" as "companions to our emotional lives [and] as provocations to thought" (Turkle, 2007, p. 5). In a similar vein, anthropologist Daniel Miller (2010) gathers stories of the objects through which people construct their identity. Collectively, these works illustrate the ways in which everyday objects are not only meaningful for their owners, but also active participants in social life.

Despite such conceptualizations, approaching objects through their sociality has yet to be substantially applied in HCI research. There are some theories that recognize objects as social actors. Suchman's work, for example, calls attention to the way that human activity requires support from material artifacts, and in doing so recognizes that action includes humans and objects as actors (Suchman, 2007). Alternatively, the concept of 'object-centred sociality' (Engeström, 2008) considers the ways people bond with, are attached to, and connect through digital objects in online social networks, such as photos. This recognizes that social networks are not only made of people but also mediated by shared objects.

A concept of social objects, however, has yet to be adequately transferred into the contexts of the IoT, though clearly has increased significance as computation becomes increasingly embedded within physical objects.

It is important to note that an understanding of the sociality of objects is not to anthropomorphize objects – that is, to treat them as if they were human. But nor is it to cast objects simply as mediators of human social interaction. Yes, every object embodies histories of human thought, design, and labor (Latour, 2005). Objects establish and maintain social relationships, which includes how they are used, appropriated and understood by people, but also how they tie people together, shape our place in the social world and live out a life of their own. This understanding of materiality conceives humans and material artifacts as thoroughly entwined in historical and continuous relations. There is no instance in which people exist without material objects, in which they are not surrounded, shaped and defined by their object-interactions. And whilst many artifacts and objects would not exist without human intervention, the existence of an object cannot be completely captured by its human relations.

Recently, a speculative philosophical understanding of objects living an existence that exceeds their relations with humans has emerged within the metaphysics of object-oriented ontology (Harman, 2009). The term object-oriented ontology was deliberately borrowed from object-oriented programming to highlight interaction that isn't hierarchically ordered but based upon the composition of objects themselves.

According to Harman, philosophies of technology have long noted that things possess an element that is inaccessible to us. Harman notes that this relationship is not unique to humans: *objects also withdraw from each other* (Harman, 2009, p. 196). This philosophical position has relevance for design research in a number of ways. It draws attention to the need to avoid assumptions in knowledge of 'users'. But, it also acknowledges a limitation in ever being able to fully know or encompass the complexities of use. Users exceed design, and designs can only partially address a concern. To recall the examples presented above, Memodules and TOTeM can understand only certain properties of objects: the biographies that have been encoded into their attached RFID tags.

Our own use of the phrase 'object-oriented ethnography' in this paper contributes to this intellectual tradition, drawing attention to ethnographic enquiry that orients towards objects rather than people, seeking to investigate their social lives. Our emphasis of '*social* things' refers less to their importance for human users than their capacities for sociality in themselves, yet we acknowledge this remains an always partial endeavor.

This approach to material artifacts is complemented with, and complicated by, a philosophical distinction between 'objects' and 'things' (Heidegger, 1971; Latour, 2005). This distinction is often traced to the etymology of the word thing, which refers to archaic forms of assembly or gathering. Latour cites the Nordic parliamentary terms that remain close to this etymology of governing assemblies:

Storting (Norway), *Althing* (Iceland), *Ting* (Isle of Man) (Latour, 2005). *Things*, in this line of thought, are assembled collectives of people and materials, which exceed their material limits through their distributed social relations and material interactions. *Objects*, on the other hand, are discrete and stable entities, often treated as so many 'black boxes' (Latour, 2005). Bill Brown (2001) uses a window as an example of this distinction: we look *through* a window-as-object, and look *at* a window-as-thing. This philosophical distinction has important implications for how we name, understand and research the so-called Internet of Things, and how we engage, support or enhance this sociality.

Understanding 'things' as active users of computational devices extends and further complicates (productively) the field's understanding of interaction. As HCI research has taken into account multiple users, contexts of interaction, and ethics of participatory design, the concept of 'social object' that we present here extends an awareness of the embedded nature of human-computer interaction. We present three examples of prototypes that have been developed, which we argue attempt to translate more directly the concept of 'social objects' or 'object-centered sociality' (Engeström, 2008), within the contexts of ubiquitous computing and the IoT.

The History Tablecloth

By augmenting objects with capacities for communication, such intimate designs recognize the significant role objects play in mediating interpersonal relationships between people, but also the ways objects are active participants in social relationships. A complementary design approach to support object communication can be found in the History Tablecloth (Gaver et al., 2006). Using an electroluminescent material display, the tablecloth lit up places on its surface where objects had been placed, which slowly dimmed after their removal.

The tablecloth was used to explore ways to make the movement and use of objects in the home perceptually salient. The tablecloth's perception of interaction was fairly limited: it was able to sense only the location of weights placed on or removed from its surface. Nevertheless this limited perceptual repertoire gave birth to a rich sense of object relations when installed in a test home for four months. In addition to casting 'haloes' around plates, papers, and laptops, the cloth would also detect people leaning on the surface.

The interpretations that the test users and their visitors drew from their interaction with the tablecloth were remarkably rich. Some people took the tablecloth as a means of highlighting clutter in the home; some saw the illumination as a sign of greeting. Some of the events that the designers saw as glitches were appreciated for their aesthetic beauty by the users. On one occasion an empty wine glass was not detected; when wine was poured into it, however, the tablecloth lit up.

We suggest this is an example of an object-oriented design, which does not aim to augment objects to include them in tangible communication between people, but instead augments the spaces/surfaces that objects inhabit in order record the presence and trace of objects as they participate in domestic routines. The 'sociality' of the History Tablecloth, then, is one that includes a wide variety of objects, people, as well as their home environment.

Connectibles

Connectibles (Kalanithi and Bove, 2008) is a 'tangible social network', which uses physical objects to represent social relationships. The design draws on gift-giving practices, whereby physical tokens exchanged between people become the connectible objects that physically represent and operate as the interface for a person's social network. The tokens are described by the authors as 'social objects' because they symbolically represent a social connection or relationship, and the system as a tangible network because it moves the social network (considered both in terms of relationships and in terms of a communication platform) off the PC and into the tangible world.

The Connectibles project draws on a substantial anthropological literature on *gifts* as a special category of social object. Gifts feature prominently in the anthropological research of Marcel Mauss and others. Importantly, gifts do not simply represent social ties but actively create and maintain them. A wedding ring, which Kalanathi and Bove (2008) give as an example of a social object, does more than simply *represent* a marriage; an exchange of rings is an important *performance* of marriage.

The model of sociality that the Connectibles project provides remains a human-centred, rather than an object-centred one. This is because, while users exchange physical artifacts, these tokens exist to visually *represent* human social relationships in the physical world, rather than *perform* the complex social relationships between humans and non-humans.

Keynect

A more recent tangible social network design, Keynect (Pandey and Srivastava, 2011), attempts to overcome this exclusion of everyday objects by building a system around an ordinary and shared real-world object, namely sets of communal keys in an organizational setting. This system utilizes the interactions people have with and share through the keys as a way to share content about people's connections within and experiences of their local setting.

Whilst this project is clearly oriented around everyday objects it remains focused on the connections between people, and the object is a generic item that serves as a conduit for these connections. The somewhat random movement of keys between rooms, teachers, and hooks is a source of intrigue and *serendipity* for its users (Leong et al., 2006). The aim is for a form of sociality based upon

randomness, coincidence, and surprise, rather than human intentionality.

Hello Lamppost

Building on playful social interactions, but trying to incorporate particular objects and the specificity of their locations, is a design project called Hello Lamppost (http://www hellolamppost.co.uk/). Hello Lamppost was an experimental urban design that operated in Bristol in July-September 2013, which used pre-existing identifier codes on street infrastructure to enable people to send text messages to objects such as lampposts, post boxes, bins, telegraph poles and so on.

This project aimed to challenge ideas of efficiency tied up with the smart city by thinking about the city as a platform for social play. Described by the developers as "an opportunity to rediscover your local environment, share your memories of the city and uncover the stories that other people leave behind," this project not only included objects as conduits or containers for human communication, but recognized the important role material objects play in shaping the look, feel and memories of place.

Other kinds of object-centred networks, particularly in the design and engineering professions, involve people collaborating to create new kinds of objects. Here the object speaks back to its creators, by failing to perform well until it is designed to work for the situation envisaged (Brereton and McGarry, 2000). Such situations do not remain stable however. For example, as Orr's (1996) ethnography of photocopiers and their technicians reveals, each particular photocopier has its own known character and foibles. Another kind of object-centred social network arises after design through people swapping and exchanging objects with others (gardening tools, unwanted fridges, etc.). Human sociality arises from the desire to acquire, share or dispose of an item. An inspiring example is a community that uses 3D printers to make mechanical hand prostheses for children and adults. As children grow they can send in their old hands and swap them for a larger size (www robohand.net).

In each of the projects surveyed above – the History Tablecloth, Connectibles, Keynect, and Hello Lamppost – a vision of social relations with and through objects emerges. Each, as we discussed, offers provocative possibilities for object-centred sociality. Yet each project in its own way falls short of a true object sociality. The History Tablecloth adds illuminated 'auras' to objects placed upon it, creating a table with a form of memory, yet this memory is primarily for the aesthetic appreciation of its human users. Whether through the special power of gift-giving or serendipitous surprises, the Connectibles and Keynect projects seek to bring social networking away from computers and into the 'real world' of tangible artifacts. Hello Lamppost was a brief installation that playfully tried to include street furniture, giving it a voice the collective formation of locative social communications and memory.

Despite the limitations of the tangible social networks that they assemble, these evocative examples suggest a number of considerations for developing more object-centered social interactions or networks, which more effectively and creatively embrace particular everyday objects, their social interactions, and networks of relations with both people and other objects.

METHODOLOGICAL RESPONSES TO SOCIAL THINGS

We (and others) have argued that the digital augmentation of everyday objects begins to blur and extend the boundaries of the 'user' from people to things (Fallman, 2011). A conceptual shift that regards objects as users in turn implies a methodological re-orientation towards objects that explores their specific and contextual requirements.

Social objects, for example, call for a participatory design approach that includes efforts to address the concerns of objects in shaping how technologies are imagined, realized and researched. Participatory design has drawn on theories of socio-materiality and assemblage in approaches to 'design things' (Binder et al., 2012; Ehn, 2008), which considers the bundles of people and materials that are intertwined and drawn together in both the process of design and ongoing in the process of appropriation. There are opportunities for extending such participatory design considerations in the contexts of the IoT. In this section we discuss two participatory approaches to the 'internet of social things'. The first is a design consideration for the increasingly more-than-human users of new technological devices. The second relates to methodology, and suggests the usefulness of what we describe as an object-oriented approach to ethnography for the field.

Designing for things

As designers of interactive technologies we need to take account of a world that is already replete with material artifacts that we have established relationships with and maintain relationships through. Interfaces between digital technologies and non-digital objects have increasingly become a part of design theory and research, with attendant vocabularies focused on tangible, embodied and material interactions (Wiberg and Robles, 2010). This varied literature has developed our conceptual understanding of and imagination for the physicality of objects, bodies and materials in interaction design. Nevertheless, concepts for analyzing and understanding the broader social capacities of material objects remain underdeveloped within HCI and IoT design.

Figure 1: A landline telephone gathers other objects around it.

Figure 2: Multiple magnifying glasses reside where they are most frequently used

To date, HCI has tended to use one conceptual language for describing the relations and interactions between human users and computer objects, and another conceptual language for describing the relations between various software and programming objects. In the contexts of the IoT and a consideration of how the sociality of objects may be supported through IoT design, it may be productive to experiment with, rather than keep separate, such relational concepts and vocabularies. The term 'object-oriented' is an example of such an approach to conceptual dialogue.Michel Callon (1986) calls this approach 'generalized symmetry'. In his classic study of a scallop-fishing industry in France, Callon applies the term 'enrolment' to the work of scallop traps, union representatives, natural scientists and the sociologists' own problem. Callon argues for a methodological openness to the kinds of actors and activities that might be deemed appropriate for research.

The design of interactive artifacts, and a social IoT, needs to consider how objects already exist in established networks of relationships with people and how this sociality can be incorporated in situated, engaging, shared and meaningful ways. This raises practical issues, such as how to retrofit and transform existing everyday objects into computationally interactive things, and risks compounding the problems of building novel tangible interfaces, which are time consuming, complex, and require technological expertise (Mugellini et al., 2007).

Such computational materiality also raises ethical challenges, which consider how interaction design can be sensitive to the situation in which it intervenes, a situation typically already full of objects, people and materiality. Fallman, for example, poses a number of challenges for what is a good or ethical design in the contexts of material objects enhanced with digital capacities (Fallman, 2011). Drawing on philosophies of technology (Heidegger, 1971) that re-appraise our relations with technology, he suggests that these trends are raising ethical challenges for how we engage and design for both people and objects. In particular, he suggests these contexts are blurring design experiences from any other experience. The tentative approach he offers for a world of interactive artifacts is designs that foster relationships between users, designers, artifacts and contexts.

An Object-oriented Approach to Ethnography

By exploring the objects we live with, the ways they materially inhabit and socially share our lives, we may find opportunities for augmenting things which complement the current focus on the design of smart devices. We describe this approach to household technology research as object-oriented ethnography. Building on methodologies for ethnographic fieldwork, object-oriented ethnography is attuned to interrelations between human and non-human actors.

There is a history of ethnography-inspired research in HCI and related fields that looks at the social history and relations of technologies, which our object-oriented approach draws on and contributes to. Technology biographies and tours, for example, have been developed within HCI to trace the changing uses and cultural contexts of technologies within the home (Blythe and Monk, 2002; Nansen et al., 2011). This approach emerged from work in the social sciences exploring the wider arrangements and meanings of objects in the home, and been used to study the broader ecologies of media domestication (Nansen et al., 2011). Outside the home, Robertson et al. (2005) piloted such an approach by examining the contents of people's bags in order to understand the physical resources used by people in managing their mobility.

Object-oriented ethnographies build on this work to more carefully consider and accommodate objects in research by exploring the particular ways everyday objects are physically handled, routinely used, and socially shared. An object-oriented ethnography attempts to understand artifacts as the 'things' that help constitute social relationships. It raises a number of theoretical, methodological and practical challenges for HCI research: how to conceive of and conduct research with everyday objects in a meaningful and sympathetic way?

Figure 3: Kitchens are a major site of sociality with objects.

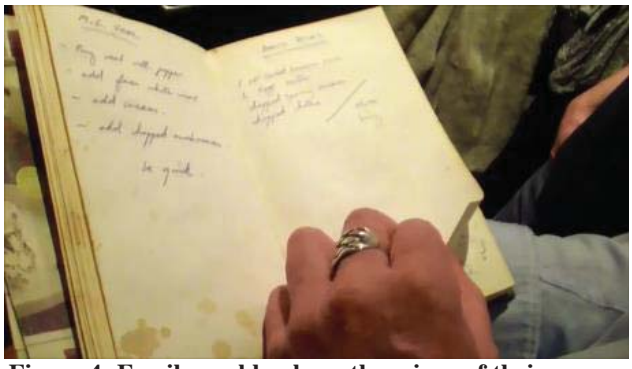

Figure 4: Family cookbooks gather signs of their use over time.

Such object-oriented research perspectives could assist in discovering the role everyday objects play in social and material interactions, and finding ways to support these roles by augmenting objects with digital technologies.

The home is a prominent domain for the IoT vision of digitally-connected and smart objects, making everything from the utensils we cook and eat with, to the furniture we sit on, more intelligent and able to sense environmental data, store and process information, communicate in networks, and perform actions (Venkatesh, 2008). Anticipating a future of smart houses is not a new thing, though we do seem to be drawing closer to this vision through the emergence of home networking protocols and the manufacture smart appliances Series. While the home is not the only potential site for the study of object sociality, it does provide a domain rich with meaning, improvisation and entanglement.

We present several projects where we have used object-oriented ethnography in the home: investigations of everyday media ecologies, adaptations and micro-inventions by older people, and devices for cooperative interaction in the kitchen. While none of these is specifically related to IoT, we believe that design for objects should be guided by an understanding of the already-existing social relationships between objects, users and their environments. Object-oriented ethnography therefore is a means of discovering, understanding and conceptualizing objects to inform digital augmentation.

Researching older users' technological environments

We are exploring the many habituated objects, devices and technologies that are adopted and adapted by older people to support their independent living as they age (Brereton, 2013; Vaisutis et al., 2014). By asking people about their most important and favorite household objects, this project explores how objects are incorporated into home routines and how in turn they shape how people live in their homes. Learning about the diverse objects in people's homes, and the often idiosyncratic interactions that emerge in relation to them, this ethnographic research provides insights into the qualities of objects themselves, how elderly people configure them to suit their embodied habits, domestic spaces and social relations over time.

In turn, it might help us to better understand how to design new IoT technologies that will become habituated and support social connection and independence.

Brereton (2013) describes the situated use of technology in the home, with one elderly participant taking the researcher through her home, pointing out the devices that she uses in order to make her life easier. Many are physical, mechanical or analogue devices, such as kettles, keys, and landline telephones (see figure 1). Technological development seems to drive toward convergence in a few digital multi-purpose devices that emphasize information and media for use at one's fingertips. Such devices, by virtue of their general purpose utility can fail to recognize the materiality of the world into which they are embedded.

Brereton's respondent, by contrast, had a kettle in both the bedroom and the kitchen, so that she could make her first cup of tea without leaving the bed. Likewise, magnifying glasses are distributed around the house, where they are most likely to be needed (see figure 2).

Object-oriented sociality in the kitchen

We are also currently exploring the use of kitchen objects and technologies by families preparing and cooking food together in domestic kitchen spaces. This project is looking at the social and physical interactions that occur within families and kitchens when cooking together, by touring kitchens, interviewing the family about their cooking habits and traditions, and then observing the preparation of a typical recipe. During the tour, interview and observation we are particularly focused upon the significant objects and technologies that reside there, their origins and purposes, and how they are handled, habituated and embodied as part of cooking practices and routines.

Whilst kitchens have a long history of technology design and intervention, those interventions have been critiqued for an emphasis on efficiency or utilitarian outcomes rather fostering social interactions, relationships, and experiences (Bell et al., 2003; Grimes and Harper, 2008). Through attention to objects, we aim to be sensitive to the various inhabitants and habits of kitchens in order to identify opportunities for tangible technology design that may

augment familial cooking traditions, kitchen interactions and cooking together (see figure 3).

For example, through this approach we identified the *homemade cookbook* (see figure 4) as a significant material and cultural artifact in the family kitchen (Davis et al., 2014). A homemade cookbook, in which family recipes are compiled and shared over time, is a particular and evocative example of the ways in which objects both embody and symbolize family cooking history and knowledge. We explored the use of homemade cookbooks, and considered how technology designs might be sensitive to and support their assembly, materiality, retention and heritage.

Object-oriented ethnographies offer a novel lens for informing design research in the contexts of the emerging IoT. By exploring the objects we live with, our relationships with them, and the ways they materially and socially inhabit our homes we may find opportunities for augmenting things to complement the current focus on the design of new or smart devices. Whilst object-oriented ethnography raises a number of theoretical, methodological and practical challenges for HCI, which have been noted here, there remains an ethical question for the digital augmentation of objects. It is important that we maintain an awareness and sensitivity to the material and social qualities of everyday objects so that we enhance or complement these rather than disrupting or conflicting with them (Chi et al., 2007; Vaisutis et al., 2014).

CONCLUSION

In this paper we have argued that IoT research and design could benefit from an expanded understanding of *social things*. We described some projects that add a communicative layer to existing artifacts in attempt to understand and complement the ways in which material objects already play a part in social relations. The 'object memory' projects discussed here illustrate the complex ties between human, material and computational memory.

We have drawn on literature in anthropology, material culture studies and technology studies to demonstrate the ways in which material objects and human social relations are understood to be mutually co-constitutive. While this is familiar from the work of Suchman, it becomes even more pressing in this historical moment because of the number of new means of interaction available to humans and objects.

Due to the proliferation of internet-enabled artifacts, both purpose-built and retrofitted, the key concept of the *user* deserves further consideration. In particular, the user of technology can no longer be presumed to be human. We present the concept 'social things' as a means of accounting for this kind of agency.

We have discussed the concerns that follow from an understanding of social things. Firstly, design practice needs to account for potentially non-human users of new IoT devices. Secondly, attention to the social lives of objects suggests new methodological directions for HCI research. A number of projects, which we describe as forming an object-oriented approach to ethnography, explore the ways in which objects help humans to make meaning, maintain relationships, and work together. While expanding our attention to and investigation of objects and their interrelations, it remains important to pay attention to relations of power between humans that are afforded by various kinds of object networks.

The 'Internet of *social* things' concept which we offer hopes both to spur designs oriented towards things, as well as to invite methodological reflection on the 'things' that make up the Internet of Things.

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REFERENCES

Ashton, K. That 'internet of things' thing. *RFiD Journal*, *22* (2009), 97-114.

Barthel, R., Mackley, K.L., Hudson-Smith A., Karpovich, A., de Jode, M., and Speed, C. An internet of old things as an augmented memory system. *Pers Ubiquit Comput 17* (2013), 321–333.

Bell, G., Blythe, M., Gaver, B., Sengers, P., and Wright, P. Designing culturally situated technologies for the home. *Ext. Abstracts CHI 2003*. ACM Press (2003), 1062-1063.

Binder, T., De Michelis, G., Ehn, P., Jacucci, G., Linde, P., and Wagner, I. What is the object of design? *Ext. Abstracts CHI 2012*. ACM Press (2012), 21-30.

Blythe, M., and Monk, A. Notes towards an ethnography of domestic technology. *Proc. Designing interactive systems*. ACM Press (2002), 277-281.

Brereton, M. Designing from Somewhere: A located, relational and transformative view of design. In J. Löwgren, L. Malmborg, and T. Binder (Eds). *(Re-) searching a digital Bauhaus*. London: Springer-Verlag (2009), 99-119.

Brereton, M. Habituated objects: Everyday tangibles that foster the independent living of an elderly woman. *Interactions* July/August (2013), 20-24.

Brereton, M., and McGarry, B. An observational study of how objects support engineering design thinking and communication: implications for the design of tangible media. *Proc. SIGCHI*. ACM Press (2000), 217-224.

Brown, B. Thing Theory. *Critical Inquiry 28*,1 (2001),1-22.

Callon, M. Some Elements of a sociology of translation: domestication of the scallops and the fisherman of St Brieuc Bay. In J. Law (Ed.), *Power, action and belief: a*

new sociology of knowledge? Routledge (1986), 196 – 223.

Chi, P. Y. P., Chen, J. H., Liu, S. Y., and Chu, H. H. Designing smart living objects–enhancing vs. distracting traditional human–object interaction. In *Human-Computer Interaction. Interaction Platforms and Techniques* (2007), 788-797.

Davis, H, Nansen, B, Vetere, F, Robertson, T, Brereton, M, Durick, J, and Vaisutis, K. Homemade cookbooks: A recipe for sharing. *Proc. DIS 2014,* ACM Press (2014), 73-82.

Dourish, P., and Mazmanian, M. Media as material: Information representations as material foundations for organizational practice. In P. R. Carlile, D. Nicolini, A. Langley and H. Tsoukas (Eds.), *How Matter Matters: Objects, Artifacts and Materiality in Organization Studies*. Oxford University Press (2013).

Ehn, P. Participation in Design Things. *Proc. Participatory Design Conference*. ACM Press (2008) 92-101.

Engeström, J. (2008) Social Objects: What Beach balls and Potatoes Can Teach Us about Social Networks. Slideshare. http://www.slideshare.net/rashmi/jyri-engestrom-social-objects (retrieved July 1, 2013).

Fallman, D. The new good: Exploring the potential of philosophy of technology to contribute to human-computer interaction. *Proc. CHI 2011*. ACM Press (2011), 1051-1060.

Gaver, W., Bowers, J., Boucher, A., Law, A., Pennington, S. and Villar, N. The history tablecloth: illuminating domestic activity. *Proc. DIS 2006*. ACM Press (2006), 199-208.

Greenfield, A. *Everyware: The Dawning Age of Ubiquitous Computing*. New Riders Publishing (2006).

Grimes, A. and Harper, R. Celebratory technology: new directions for food research in HCI. *Proc. CHI 2008*, ACM Press (2008), 467-476.

Harman, G. *Prince of Networks: Bruno Latour and Metaphysics*. re.press (2009).

Heidegger, M. 1971. The Thing, in *Poetry, Language, Thought*, trans. A. Hofstadter. Perennial (1971), 174-82.

Kalanithi, J. J. and Bove, V. M. Connectibles: Tangible social networks. *Proc. TEI 2008*. ACM Press (2008), 199–206.

Knorr-Cetina, K. Sociality with Objects: Social Relations in Postsocial Knowledge Societies. *Theory, Culture and Society*, *14*, 4, (1997), 1-30.

Latour, B. From Realpolitik to Dingpolitik. How to Make Things Public. An Introduction, in *Making Things Public. Atmospheres of Democracy*, B. Latour and P. Weibel, Eds. MIT Press (2005), 1-31.

Martinussen, E. S. and Arnall, T. Designing with RFID. *Proc. TEI 2009*. ACM Press (2009), 343–350.

Leong, T., Vetere, F., and Howard, S. Randomness as a resource for design. In *Proc. DIS 2006*, ACM Press (2006), 132-139.

Miller, D. *Stuff*. London: Polity (2010).

Mugellini, E., Rubegni, E., Gerardi, S. and Khaled, O. A. Using personal objects as tangible interfaces for memory recollection and sharing. *Proc. TEI 2007*. ACM Press (2007), 231–238.

Nansen, B, Arnold, M, Gibbs, M, and Davis, H. Dwelling with Media Stuff: Latencies of Materiality in Four Australian Homes. *Environment and Planning D*, *29*, 4 (2011), 693-715.

Odom, W. and Pierce, J., Improving with age: designing enduring interactive products. *Ext. Abstracts CHI 2009*. ACM Press (2009), 3793-3798.

Orr, J. *Talking about machines: an ethnography of a modern job*. Ithaca: ILR Press (1996).

Pandey, Sumit, and Srivastava, S. Keynect: tangible social network. *Proc. Creativity and Innovation in Design*. ACM (2011), 347-350.

Robertson, T., Kan, M., Sadler, K., and Hagen, P.. Uncovering traces of mobile practices: 'the bag study'. *Proc. OzCHI 2005*. ACM Press (2005), 1-4.

Robles, E., and Wiberg, M. Texturing the "material turn" in interaction design. *Proc. TEI 2010*. ACM Press (2010), 137-144.

Rosner, D., Blanchette, J., Buechley, L., Dourish, P., Mazmanian, M. From Materials to Materiality: Connecting Practice and Theory in HCI. *Ext. Abstracts CHI 2012*. ACM Press (2012), 2787-2790.

Suchman, L. *Human–machine reconfigurations: Plans and situated actions*. Cambridge University Press (2007).

Turkle, S. (Ed.) *Evocative objects: Things we think with*. MIT Press, (2007).

Vaisutis, K., Brereton, M., Robertson, T., Vetere, F., Durick, J. Nansen, B., and Buys, L. Invisible connections: Investigating older people's emotions and social relations around objects. *Ext. Abstracts CHI 2014*. AC Press (2014).

Venkatesh, A. Digital Home Technologies and Transformation of Households. *Information Systems Frontiers,* 10 (2008), 391–395.

Wiberg, M. Methodology for materiality: interaction design research through a material lens. *Personal and Ubiquitous Computing, 18* (2014), 635-636.

Wiberg, M. and Robles, E. Computational compositions: aesthetics, materials, and interaction design. *International Journal of Design, 4*, 2 (2010), 65-76.