

Object Geography: The Internet of Things

To what extent can the technological and cultural shift in ubiquitous computing, known as the Internet of Things, provide new insights into how objects that have informational shadows can contribute to the social production of space?

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1. Proposed Study

This report details the work covered during the first year of my PhD in Architecture, undertaken at Edinburgh College of Art under the supervision of Dr. Chris Speed, Prof. Paul Jenkins and Prof. Richard Coyne.

1.1 Title

Object Geography: The Internet of Things.

1.2 Introduction

The field of human geography focuses on 'how we make places, how we organize space and society, how we interact with each other in places and across space, and how we make sense of others and ourselves in our locality, region, and world'. In the study of human geography we are constantly reminded of how people shape their world and of how people and places vary across time and space. Places are constantly changing and people are responsible for these changes. People create cultures, values, aesthetics, politics, economics and more, and each of these affects and shapes places (Fouberg, et al. 2010).

Objects already play a unique role in our social networks and have strong ties to identity and memory (Draaisma 2000; Henare et al. 2007; Hoskins 1998; Kwint et al. 1999; Miller 2008; Turkle 2007), space (Baudrillard 1996; Bollas 2009) and value (Appadurai 1986). Within all of these contexts a human agent is required to locate the object within a network and imbue or interpret any agency it might have. Through new technologies being introduced as part of the development in the manufacturing of objects, we can begin to see a technological framework that offers a potential for objects to express their own agency (relating to both Actor-Network Theory and Networked Objects) and become a significant actor in a network.

The thesis will focus on how the technological and cultural shift in ubiquitous computing, known as the Internet of Things, will change our understanding of an object's role in the composition of a network. Through examining the Internet of Things in combination with Actor-Network Theory and Human Geography, this author will argue how objects that have data shadows will contribute to the social, economic and environmental production of space.

2. Framework and Area of Study

2.1 Internet of Things

This research is located within the emerging technical and cultural phenomenon known as the 'Internet of Things' (IOT). The term is attributed to the Auto-ID research group at MIT in 1999, and was explored in depth by the International Telecommunication Union who published a report bearing the same name at the United Nations net summit in 2005. The term, 'Internet of Things', refers to the technical and cultural shift that is anticipated as society moves to a ubiquitous form of computing in which every device is 'on', and every device is connected in some way to the Internet. The specific reference to 'things' refers to the concept that every new object manufactured will also be able to be part of this extended Internet, because they will have been tagged and indexed by the manufacturer during production. It is also envisaged that consumers will have the ability to 'read' the tags through the use of mobile 'readers' and use the information connected to the object, to inform their purchase, use and disposal of an object. Further still, every object that comes close to another object, and is within range of a reader, could also be logged on a database and used to find correlations between owners and applications.

Radio Frequency Identification (RFID) is seen as being a key enabler in the Internet of Things due to its ease of distribution, low cost, technological simplicity and is therefore a logical candidate for bottom-up tracking and tracing of things, and the ways in which things move around; in boats, in trucks, in planes, in hands (of human beings). As a pull technology, the RFID reader emits energy so that a tag provides its unique number, identifying itself. In combination with the Electronic Product Code, the next generation of production identification that identifies objects (items, cases, pallets, locations etc) in the supply chain (GS1, n.d.), it becomes possible, via an Object Name Server (ONS) the method behind mapping the EPC of the object to the IPv6 address in a database, and Physical Markup Language (PML) based on XML, to represent data about an object (Garfinkel, 2006). This means you can track a bottle in your room, provided there is a reader in your door, floor or building, and through a simple web query it can be accessed via the web, for example from Tokyo (Kranenburgh, 2007). The Internet of Things is an all-encompassing framework to reflect on and design towards more digital connectivity; a system that is local and global, accessible in real-time from any location.

2.2 Ubiquitous Computing

The Internet of Things offers a new era in ubiquitous computing and communications that will transform the corporate, community and personal spheres that we inhabit. Ubiquitous computing, also known as ambient, physical, embedded, environmental, tangible or pervasive computing (Greenfield 2006; McCullough 2004), refers to how individual devices and everyday objects might communicate and process information, creating a world in which things can interact dynamically. Weiser explored enhanced computer use through the increasing 'availability' and decreasing

'visibility' of processing power. In other words, in his view the computer as a dedicated device will 'effectively disappear' (Greenfield 2006, p.1), while its information processing capabilities will be increasingly available throughout our surroundings. 'The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it' (Weiser, 1991).

As the Internet grows, will we see it encompass more and more elements of the real world (Landt 2003), 'ubiquitous means not merely in every place, but also in everything' (Greenfield 2006, p.11), and therefore the abstraction has to be more complex too. The Internet of Things, through item based tagging and identification, will take ubiquitous computing - anytime and anywhere communications - to the next step in networking: 'anything communications'. It builds upon the success of mobile and Internet networks (ITU 2006) by expanding the world's networks even further. Personal computers dealt with the assumption that everything one needed was stored locally. Networked computers built upon that, assuming everything one needed could be made universally accessible on the Internet. Ubiquitous computing furthered this notion allowing you to take the Internet with you out into the real world, accessible through mobile devices.

As communications become increasingly ubiquitous in everyday life; 'ordinary objects, from coffee cups to raincoats to the paint on the walls, would be reconsidered as sites for the sensing and processing of information' (Greenfield 2006, p.11), the Internet of Things presents a framework in which computer devices can be embedded in everyday objects, invisibly at work in the environment around us; in which intelligent, intuitive interfaces will make computer devices simple to use and unobtrusive; and in which communication networks will connect these devices together to facilitate anywhere, anytime, always-on communications (Weiser, 1991). When we look at what could be described as 'Thing centered computing', we see an 'expanded' Internet, able to detect and monitor changes in the physical status of connected things (through sensors and RFID) in real-time.

The creation of the Internet of Things will entail the connection of everyday objects and devices to all kinds of networks, e.g. company intranets, peer-to-peer networks and even the global Internet. In this way, the 'virtual world', would 'map' the 'real world', given that everything in our physical environment would have its own identity in virtual cyberspace, enabling communication and interaction between people and things, and things themselves. If humans are the only internet users of the future, then the total user base might conceivably double, but is unlikely to go beyond two billions active users in the near future (ITU, 2005). On the other hand, if 'things' become active Internet users on behalf of humans, then the number of active connections could be measured in terms of tens or hundreds of billions. Japan's Ubiquitous ID Centre, for instance, have implemented a 128-bit addressing system UCode, for tagging individual objects with an Electronic Product Code which by some calculations would allow for a theoretical 340,000,000,000,000,000,000,000,000,000,000 codes to be assigned, permitting a trillion

tags to be assigned every day for a trillion years, and still have some left over (Sakamaura, 2005). Embedded intelligence at the edges of the network in combination with empowering things to detect and monitor their environment through sensors will enable the network to sense, react and respond to stimuli. The Internet of Things leads us into a new era of ubiquity, where the 'users' of the Internet could be counted in billions and where humans may become the minority as generators and receivers of traffic, and instead most of the traffic could flow between devices and all kinds of 'things'.

2.3 Networked Objects

The IOT offers the opportunity to intensely map the real world onto cyberspace with increasing detail, through the ability to uniquely identify anything immediately via a machine-readable identification method such as RFID or a high-density visual code. Once you have this capacity, you can attach meta information to it and create a digital representation. Adam Greenfield (2006) describes this process as endowing an object with an 'informational shadow' and notes "the significance of technologies like RFID and 2D bar-coding is that they offer a low-impact way to 'import' physical objects into the datasphere." Anders, Sterling and Bleecker have all attempted to address the issue of virtual representations of physical objects, and have discussed this concept further.

2.3.1 Cybrids

Peter Anders (2001) termed Cybrids to represent a link between concrete objects and abstract data, which produce a hybrid of physical and electronic spaces that investigate how cyberspace can work in a way that is native to ways we think and live with space. Anders talks of a 'cybrid reality', which could easily be interpreted as an early vision of the Internet of Things, in which 'I have a physical object here that notes my handling of it and displays its contents to me in this way'. He discusses the ability for an object to be a methodology for 'mapping of space and information', and in this context, changes the informational processes into something that is 'spatial in nature' and in 'direct relationship with the physical'. Resulting in a 'virtual and physical world that correspond with each other, comprised of 'entities' that 'cybridize within that world'.

2.3.2 Spimes

'Spimes', termed by Bruce Sterling (2005), discusses a currently theoretical object that can be tracked through space and time, and throughout the lifetime of the object. Sterling sees 'Spimes' resulting through the convergence of emerging technologies, related to both the manufacturing process for consumer goods, and through identification and location technologies. These technologies are specific to constructing the framework that is the Internet of Things, a platform in which every object manufactured will be able to be tracked from cradle to grave, through manufacturer to distributor, to potentially every single person who comes in to contact with it following its purchase. The entire existence of an object can be recorded, archived and searched, from before it was made (its virtual representation), through its manufacture, its ownership history, its physical location, until its eventual

obsolescence and breaking-down back into raw material to be used for new instantiations of objects. '[Spimes] are regarded as material instantiations of an immaterial system', they're virtual objects first and actual objects second, which 'begin and end as data' (Sterling 2005, p.11). Sterling predicts how the presence of 'Spimes' will completely change our relationships with our possessions; 'I have an Internet of Things with a search engine. So I no longer hunt anxiously for my missing shoes in the morning. I just Google them.' (2005, pp.93-94). Objects within the Internet of Things, connected to a host of machines that can crunch the complexities of the patterns of relationships formed between person and object, and objects themselves, will allow for the relationships you have with them to appear simpler, more immediate and for far more complicated relationships to be perceived and created.

2.3.3 Blogjects

'Blogjects', termed by Julian Bleecker (2006), distinguishes between 'Things' connected to the Internet from 'Things' participating within the Internet. 'Blogjects don't just publish, they circulate conversations. Blogjects become first-class a-list producers of conversations in the same way that human bloggers do — by starting, maintaining and being critical attractors in conversations around topics that have relevance and meaning to others who have a stake in that discussion' (2006, p.4). Bleecker extends Sterlings proposal of a 'Spime' by adding agency to its characteristic. The characteristics of agency involve an ability to be decisive and articulate, to encourage action and a Blogject's intellect is their ability to effect change. Bleecker argues an object's agency is attained through the consequence of their assertions, and through the significant perspective that they contribute to meaningful conversations. In the Internet of Things, this kind of agency happens within the arena of the networked public; streams, feeds, track-backs, permalinks, Wiki inscriptions and blog posts. Things that matter inflect the course of social debate and discussion, and cannot help inflicting local and global change. Bleecker concludes that if an object were able to comment on the world around it, and through that commenting create change, then the agency between subject and object, human and non-human would be completely transformed.

2.4 Network: Structure and Agency

The Internet of Things is a starting point for rethinking our relationship with the physical world, as we begin to imagine scenarios where the physical and digital spheres collapse onto each other. According to the propositions of Anders, Sterling and Bleecker, objects now have multiple trajectories through time. They become an interface for data storage and retrieval – they have memory and they can publish. Objects are locatable in space, and more importantly they have an "awareness" of the environment they inhabit. Through adding a whole array of everyday things as nodes of the Internet, who begin to deal with the notions of space, time, memory and agency, new connections arise that lead us to question the composition of a network.

Networks are formally defined as a set of nodes or network members that are tied by one or more specific types of relations. By focusing on the key idea of actors and how they are connected, we gain insight into the structure of social interactions - on the individual level as well as the groups and institutions.

2.4.1 Structure

Lopez and Scott (2000) as cited in Stones (2007 p.4870) argued that there are two primary ways of conceptualizing structure, both deriving from Durkheim. The first is the relational notion of structure, referring to networks of social relations that tie people together into groups and social systems. George Simmel similarly emphasized relationships, conceiving of society as a dynamic of complex social forms and interactions. These may involve smaller or larger numbers of people, or specific types of association, which structure the way which agents behave in one another's presence. Norbet Elias's figurational sociology likewise emphasised the webs and networks of relationships within which individual agents do act.

The second notion of structure, the institutional, refers to the beliefs, values, symbols, ideas, and expectations that make up the mutual knowledge of the members of society and allow them to communicate with each other. Durkheim (1984) referred to this dimension of structure as a society's 'collective representations'.

Both approaches to structure are compatible with another metaphor routinely associated with structure: pattern. The notion of pattern is often included in the very definition of structure. For example, social structure may be seen as 'a system of patterned relationships of actors in their capacity as playing roles relative to one another' (Parsons 1945, cited Stones 2007 p.4870). The key notion here is the relationship of the actors, therefore it is important to identify what can be considered an agent in the structure.

2.4.2 Agency

A crucial feature of an agent within a structure is that it can interact; it can pass on informational messages to other agents and act on the basis of what it learns from these messages (Gilbert 2008, p.5). Gilbert notes that these messages may represent a dialogue, or a more indirect means of information flow, such as the observation of another agent, or the detection of effects on another agent's actions.

Agents are conventionally described as having the following four important features (Wooldridge & Jennings 1995, cited Gilbert 2008 p.21).

- **Autonomy** – there is no global controller dictating what an agent does, i.e. it does whatever it is programmed to do in its current situation.

- Social Ability – they are able to interact with other agents.
- Reactivity – they are able to react appropriately to stimuli coming from their environment.
- Proactivity – an agent must have a goal or goals that it pursues on its own initiative.

If we can understand a networked object as capable of possessing agency, as a result of an amalgamation of characteristics outlined by Anders, Sterling and Bleecker, then it is important to further deconstruct these features; as without consciousness then it is unlikely an object will ever possess autonomy or proactivity due to the need of human intervention to govern these two properties. Therefore a more helpful way of describing agency, within this context, is to define the following characteristics derived from Gillbert's (2008 p.11) agent based modeling.

- Perception – they can perceive their environment, possibly including the presence of other agents.
- Communication – they can send messages to and receive messages from other agents.
- Memory – they have a memory, which records their previous states and actions.
- Policy – they have a set of rules, heuristics, or strategies that determines, given their present situation and their history, what behaviors they will now carry out.

This model of agency is based on theories relating to Actor-Network Theory. Actor-Network Theory insists on the agency of nonhumans, although it is critiqued that the properties outlined by Wooldridge & Jennings relating to autonomy and proactivity, or in other words intentionality, fundamentally distinguish humans from animals or from things. In the context of Actor-Network Theory, agency is located neither in human "subjects" nor in non-human objects, but in heterogeneous associations of humans and nonhumans; it neither presupposes intentionality nor is assigned to nonhumans.

2.5 Actor-Network Theory (ANT)

The Internet of Things therefore can be most closely linked to Actor Network Theory (ANT), a method for mapping the patterns of techno-science, where networks become the substance out of which both individual identity and social organization are constructed. ANT can be seen as a tool for exploring and describing how the social is assembled by way of technologies; objects and artifacts (Latour 2005), and its import is one of agency, specifically responsibility that is distributed equally across entities, including a host of nonhuman ones not normally seen as exercising agency at all. (Bijker & Law, 1992; Latour, 1999).

In the Actor-Network Theory's analytical frame, also known as Sociology of Translation, reality is observed through interactions and is considered as the effect of heterogeneous networks. As the actors in the network can be both human and non-human, actor network theorists sometimes use the term actant to refer to such actors. Society, organizations, agents, and machines are all effects of

patterned networks generated through the interactions of actor-networks (Law, 1992). In other words they are formed by the relationship between intermediaries - 'anything passing between actors, which defines the relationship between them' (Callon 1991, p.134), actors and translation - the process of simplification and punctualisation that helps us to understand the complexity of the relationships.

Latour (2005) argues that the observation of the social can only be achieved by tracking the traces it leaves when an association is being produced between elements, and therefore ANT offers an appropriate methodological approach for analyzing networked objects in the context of the IOT; objects as actors in the network, considered to have a role within it that extends beyond their material form.

2.6 Conclusion

As objects go online they could create a new layer of complex relationships that were previously not visible in our networks. By allowing us to examine the objective pattern of interactions represented by how people to people, people to things, and things themselves are connected to one another, we'll possibly gain insights into the structure of social interactions. The structure of a network, the relations among network members, and the location of a member within a network are critical factors in understanding social behaviour. Complex, dynamic social systems are analysed in terms of stabilising and destabilising mechanisms, and traditionally it is only human agents who play strategic roles in these processes. Institutions and cultural formations of society are carried by, transmitted, and reformed through individual and collective actions and interactions. These social structures help to create and recreate themselves in an ongoing developmental process in which collective agents play constructive as well as destructive and transformative roles in the context of complex sociocultural arrangements. These arrangements of social life involve time, space and place as a constitutive factors in the construction and reconstruction of what people do and in the way they do things together, as active agents with their distinctive characteristics, motivations, and powers contributing to the reproduction and transformation of our networks.

The Internet of Things provides a possible framework that allows not only human agents but also object agents to constitute and reconstitute time-space, place and cultural forms through their interactions.

3. The Research Plan

3.1 Research Question

The main research question is:

To what extent can the technological and cultural shift in ubiquitous computing, known as the Internet of Things, provide new insights into how objects that have informational shadows can contribute to the social production of space?

In a more detailed way, the research will also answer the following sub questions:

- How can actors be identified and viewed in the field of the Internet of Things?
- What affect will an Internet of Things have on the structure, agency and pattern of a network?
- If the Internet of Things means a network can be understood as being constructed by people and objects, how does the Internet of Things affect the production of time-space and place?
- How does the Internet of Things allow objects to aid human interpretation of social relationships, and allow objects to produce emergent interpretations of their own?

3.2 Aims of Study

This thesis aims to contribute to a better knowledge of the relationship between an object and our understanding of what constitutes a network - both in terms of its structure and agency.

Furthermore it aims to examine whether The Internet of Things can provide a possible framework that allows not only human agents but also object agents to constitute and reconstitute time, space and place through their interactions.

3.3 Significance and Original Contribution to Knowledge

Since its conception in 2005 the Internet of Things has become a technical framework for extending the area of Ubiquitous Computing. On the whole the field of study sees the Internet of Things in the realm of manufacturing, its benefits amount to improving economic supply management and consumer purchasing. The author in the process of this thesis aims to combine several different areas of study, including ubiquitous computing, human geography and actor-network theory, to propose that the Internet of Things also offers new possibilities for understanding how time-space, and place is represented and produced. If an object can indeed express agency, as outlined by Bleecker, Latour, Law and Callon, then objects as well as people could be seen as playing a role in the construction and destruction of networks.

3.4 Methodology

This is a practice based research project using the creative act of digital artwork as an aesthetic base to enquire into Internet of Things, structure and agency. It merges theoretical writing on human geography, actor-network theory, sociology and philosophy with ubiquitous computing to create works of art. Each artwork can be understood as a case study, which will each seek to determine whether it is possible for an object, within the context of the Internet of Things, to play a role in the construction and destruction of social networks. A series of produced works, be it either public in nature or abstract in thinking, will engage with the notion of agency as derived from Gillbert, Latour, Law and Callon. Across the research activities it is intended that a synergy will be sought between the creation of the artworks and the reviewing and integration of the theoretical writings as outline above, with both processes informing further developments.

3.5 Proposed Chapter Outline for Thesis

1. Research Context

Chapter Content

Objects

The Internet of Things

Ubiquitous Computing

2. How can actors be identified and viewed in the field of the Internet of Things?

Chapter Content

Case Studies

Networked Objects

Take Me I'm Yours

Actor Network Theory

Agent based modeling – complex adaptive systems and co-operation

Actor Oriented, Dynamic System Theory

3. What affect will an Internet of Things have on the structure, agency and pattern of a network?

Chapter Content

Case Studies

Social network theory and analysis

National Museums of Scotland

Network Topology

Agency and intention

4 If the Internet of Things means a network can be understood as being constructed by people and objects, how does the Internet of Things affect the production of time-space and place?

Chapter Content

Case Studies

Time Geography – proximity

Production of Space

Spatial relationships

Place and Non Places

5. How does the Internet of Things allow objects to aid human interpretation of social relationships, and allow objects to produce emergent interpretations of their own?

Chapter Content	Case Studies
Individual and Social Memory	Tales of Things, Itizen, StickyBits, ThingD
Pattern	Oxfam
Emergence	Caring Memories
Power and Control	

6. Conclusions

7. Appendices

8. References

3.6 Timeframe of the Study

January 2011 – March 2011	Chapter 2
April 2011 – July 2011	Chapter 3
August 2011 – December 2011	Chapter 4
January 2011 – May 2012	Chapter 5
May 2012 – July 2012	Chapter 1 and Chapter 6
August 2012	Submission of First Draft
September 2012	Submission of Final Draft

4. Work Completed to Date

The past academic year has been dedicated to the literature review, academic papers, the presentation of two public artworks, and the ongoing involvement in 'fields' research team led by Dr. Chris Speed, and the EPSRC project TOTeM.

4.1 Papers

As part of the literature review I have produced a series of papers that reflect the research at the time of writing; the topics of which have continued to develop over the course of the year. Copies of the papers can be found in the appendices.

How I Learned to Stop Worrying and Love Tagging: Overcoming the Public Fear of Tagging Culture.

Authors: Burke, M. Shingleton, D. Speed, C.

The Memorable: Applying the Internet of Things to small communities

Authors: Shingleton, D., Sutherland, K.

Presented and published: Web Studies Congress, Mexico 2010.

Pervasive memory, locative narratives

Authors: Corino, G., Shingleton, D.

Published in Research on Education and Media Journal

4.2 Artworks

RememberMe

Presented at FutureEverything, Manchester 2010 developed by the TOTeM project, a UKRC Digital Economy funded project

The RememberMe artwork is a collaborative project with the Oxfam shop, near Contact Theatre. Leading up to FutureEverything, a research assistant will be based in the shop and recording brief stories about the donated objects into a microphone: where they acquired it, the memories attached and any associated stories. This audio clip will be linked to an RFID tag and QR code.

During FutureEverything all tagged items will then join the shop's stock. Customers, including conference delegates, will be invited to use our bespoke RFID readers, or their own smart phone to browse artifacts, displayed amongst the many thousands of other objects. Once triggered, RememberMe labeled objects, will replay the story through speakers located in the shop, evoking ghosts of the past. Tagged objects will be in the public domain for purchase by other members of the community. Our iPhone and Android apps will allow them to access the story for years to come.

Co-Cinema

Presented at Atmosphere, Inspace 2010 developed by Duncan Shingleton with the support of New Media Scotland, Inspace and the University of Edinburgh.

Co-Cinema by Duncan Shingleton is a ten minute interactive movie experience that involved three sequences from Jacques Tati films - 'Les Vacances de Monsieur Hulot', 'Mon Oncle' and 'Playtime'. The work was exhibited during the Atmosphere programme at Inspace, Edinburgh, which ran parallel with the Edinburgh Film Festival. The cinema screen was cut up into 40 pieces, each piece corresponding to a seat in the audience. Each person sitting in the audience could 'flip' their movie segment to one of three different film sequences by scanning one of three QR codes that are located next to their seat with their smartphone.

The experience began with one cohesive image, but as members of the audience 'flipped' their own parts, it became broken up as 40 people tried to watch three movies at once.

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6. Appendices