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# Software, Objects and Home Space

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# Software, objects and home space

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**Abstract**
Through a series of interrelated developments, software is imbuing everyday objects with capacities that allow them to do additional and new types of work. On the one hand, objects are remade and recast through interconnecting circuits of software that makes them machine-readable. On the other, objects are gaining calculative capacities and awareness of their environment that allow them to conduct their own work, with only intermittent human oversight, as part of diverse actant-networks. In the first part of the paper we examine the relationship between objects and software in detail, constructing a taxonomy of new types of coded objects. In the second part we explore how the technicity of coded objects is mobilised to transduce space by considering the various ways in which coded objects are reshaping home life in different domestic spaces.

## Introduction

A number of analysts have recently argued that software is increasingly making a difference to the constitution and production of everyday life, in large part because it alters the conditions through with space is beckoned into being (see Beer 2007; Dodge and Kitchin 2005a; Galloway 2004; Graham 2005; Thrift and French 2002). In their work, Dodge and Kitchin (2005a) produce a provisional taxonomy of the various ways that software is becoming embedded in the world. They detail that coded objects are items 'that use code to function or permanently store digital data that cannot be accessed without software' (p. 163); coded infrastructures are distributed 'networks that link coded objects together and infrastructure that is monitored and regulated, either fully or in part, by code' (p. 163); coded processes 'refer to the transaction and flow of digital data across coded infrastructure' (p. 164); and coded assemblages consist of the interlinking of coded objects, infrastructures and processes to produce dense networks that support particular environments or enterprises (such as an airport; cf. Dodge and Kitchin 2004). In their analysis they trace, in broad terms, how these coded objects, infrastructures, processes and assemblages work together to shape socio-spatial life with respect to different domains of everyday living (work, travel, consumption and the home). However, they provided little in-depth analysis of the nature of coded objects, infrastructures, processes and assemblages themselves.

In this paper, we more fully explore the relationship between software, objects and material spatiality, examining how the embedding of microprocessors and software algorithms into the objects people use to undertake daily domestic tasks is transforming them, imbuing them with capacities that allow them to do additional and new types of work in the world as part of diverse actant-networks. Objects, as we will illustrate, are gaining additional competencies to sense their environment, to record their own use, to take over aspects of decision-making from their human owners, and in some cases are becoming nodes in the emerging 'internet of things'[1] (Schoenberger 2002). In particular, we are interested in how coded objects beckon particular kinds of space into being through their work in the world.

The space we focus on in this paper is the home and how new coded objects are shaping home life in Western societies, on the one hand augmenting the work of existing electrical and electronic domestic technologies in producing particular spatialities and, on the other, establishing new socio-spatial arrangements. To that end, the paper is divided into two broad sections. In the first part of the paper we discuss the nature of coded objects – that is objects for which software is an essential component to their functioning – detailing the difference software makes and providing a functional taxonomy of such objects. In the second part of the paper we discuss how various coded objects beckon homes into being, thinking through how the agency of software is beginning to reshape domestic life. While much of this reshaping remains banal and occurs in subtle and often hard to discern ways, it is socially significant we argue because it marks a juncture point in the production of the so-called technological unconscious, 'the surface on which life floats' (Thrift 2004: 584). In so doing, we seek to contribute to the literatures on software and space, material geographies, and geographies of the home, and to bring them into conversation with each other. Importantly, we focus on the messily arranged here-and-now, rather than to imagine the supposed 'smart home' of the future.

**Code and (domestic) objects**

Material objects are becoming coded in two ways, firstly through 'external' processes of identification and linkage, and secondly through 'internal' embedding of software. To consider the first process: since the late 1970s and the widespread application of barcodes to mass-produced consumer goods, objects have increasingly become machine-readable through rapid and reliable reading of identification numbers placed on them. Such identification technologies include a range of different printed barcodes and the growing use of radio frequency ID (RFID) tags (cf. Dodge and Kitchin 2005b), which when combined with appropriate information infrastructures (for identification number allocation and specifying product classification formats[2]), can be consistently matched to information held in a organisation's database to reveal the identity of the object and other associated properties (such as batch number, manufacture date, shipping history, and so on). As such, it is now increasingly possible to systematically track objects through space and time in ways that were previously impossible, especially given the rise of unique indexing systems, for example that being promulgated by EPCglobal corporation to make RFID tagged goods individually recognisable any where.

The near universal application of these kinds of identification and tracking technologies has had a major impact on the workings of Western consumer societies, not least in enhancing the operational capacity and logistical efficiency of retail supply chains. Yet typically, this has remained behind-the-scenes and often at several steps removed from the home itself. The banal power of the UPC barcode, for example, may have reconfigured how we buy products but it has had virtually no effect on what we do with these products inside the home. However, emerging RFID-based technologies, according to some predictions, will have a much greater effect on domestic routines inside the home. 'Smart' packaging using RFID tags will make products automatically readable by domestic appliances, for example a ready meal will 'tell' a microwave how long it should be cooked for, the fridge will be able identify when food goes out of date and warn the household, and a new cashmere cardigan will instruct a washing machine how it should be washed so it does not shrink. The goal, as with much previous domestic technology, is to increase convenience by delegating more components of routine tasks to the machine, in this case through the 'invisible' exchange of unique identification data which enables the software in an appliance to work appropriately without explicit instruction from a human.

To what degree these archetypal 'smart kitchen' scenarios become a reality remains somewhat in future, with many technologists suggesting that they will be standard aspects of a pervasive computing society (see later). Yet bound up with the promises of greater convenience and more orderly domestic routines, is the capacity to make formally hidden and unrecorded actions newly visible to other, external organisations and to eliminate anonymity from consuming mass products because every time the RFID tag is queried it leaves behind a log. What this means, in the context of a household, is a change in the ontological status of each product that is indexed with it being knowable in new ways in terms of what information is held about it in a database - ranging from purchasing information through to a detailed usage trail and eventually disposal (so it is not just *a* bottle of whiskey in a household's rubbish bin but *the* bottle of whiskey purchased for £15.99 on the 15/12/07, at 19.54pm in the Whistlestop shop, King's Cross Station by A.N. Other). As such RFID 'smart' tagging opens up the spectre of a new frontier of potentially invasive surveillance straight into the private sanctuary of the home (cf. Albrecht and McIntyre 2005).

Second, in contrast to machine-readable objects which simply participate 'externally' in the internet of things, are coded objects which have software physically embedded into their material form, altering 'internally' their relations with the world. Most significantly, this software is used on the one hand to enhance or augment the functional capacity of what were previously 'dumb' objects enabling them to sense something of their environments and to perform different tasks, or the same tasks more efficiently, or to be 'plugged' into new distributed networks that afford some value-added dimension such as data exchange on how they are used. On the other hand it is used to underpin the invention of new classes of objects, particularly mobile devices (such as

PDAs, MP3 players, Satnav), that in some cases replace analogue equivalents (diaries and filofaxes, personal tape and CD stereos, paper maps and gazetteers) or undertake entirely new tasks. The embedding of software significantly increases the technicity (their capacity to do meaningful work in the world; Mackenzie 2003) of coded objects, enabling them to perform elements of a given task independently of human oversight.

Coded objects can be subdivided into two broad classes based on their relational capacities. First, there are *unitary objects* that rely on code to function but do not record their work in the world. Second, there are objects that have an 'awareness' of themselves and their relations with the world and which, by default, automatically record aspects of those relations in logs that are stored and re-used in the future (that we call *logjects*[3]).

*Unitary coded objects*

In broad terms unitary coded objects can be divided into those that function independently of their surroundings and those that are equipped with some kind of sensors that enable the object to react meaningfully to particular variables in their immediate environment. The former group include a digital watch, a DVD player, a radio/CD set, a digital kitchen timer, a calculator and a USB memory-stick. Code is vital to the functioning and performance of each of these items, but the object simply executes its task independently of the world around it, without recording its use, or communicating with other objects or out onto networks. Generally they have tightly circumscribed functions and limited latitude to operate automatically. The latter group includes a central heating control unit, a washing machine with sophisticated software settings, a digital camera and storage card. The central heating unit is equipped with a digital thermostat and timer that knows the time/date and senses the surrounding temperature and simple software algorithms react accordingly in relation to preset requirements of people. Similarly software in the washing machine will monitor multiple contextual parameters such as door lock, load weight and water temperature necessary for safe and effective operation without human oversight (see Table 1). The digital camera captures an image of the world using a CCD sensor[4] and measures light levels to adjust the aperture setting and the lens movement for auto-focusing, as well as monitoring remaining battery life and available storage space.

Table 1 about here

*Logjects*

The second class of coded objects differ from unitary objects in that they not only sense the world but also record their status and usage, and, importantly, can retain these logs even when deactivated and utilise them when reactivated. In key ways these logs can have a bearing on the on-going operation of the object and its relations with people or wider processes. We term such coded objects, 'logjects', drawing on Bleecker's (2006) notion of a *blogject* (where for us a blogject is one type of logject).

Bleecker defines a blogject as an emerging class of objects that generates a blog[5] of its own use and has the capability to automatically initiate exchanges of socially meaningful information – 'it is an artefact that can disseminate a record of experience to the web' (Nova and Bleecker 2006: no pagination). Bleecker characterises blogjects as objects that: (1) can 'track and trace where they are and where they've been', (2) 'have self-contained (embedded) histories of their encounters and experiences' (rather than indexical histories) and (3) 'have some form of agency – they can foment action and participate; they have an assertive voice within *the social web*' (2006: 6, original emphasis). Blogjects are things that can 'do' meaningful social acts where their actions shape how people think about and act in the world; they 'participat[e] within the Internet of social networks' (Bleecker 2006: 2). Here, Bleecker is very much interested in only certain kinds of software-enabled objects that produce streams of information very much like human's writing blogs, thus contributing to the 'ecology of networked publics – streams, feeds, trackbacks, permalinks, wiki inscriptions and blog posts' (Bleecker 2006: 9). He is very careful to delineate blogjects as political actants that contribute to debates by providing socially meaningful information, rather than being coded objects that log their use and communicate and/or analyse that data across distributed networks. While Bleecker's notion of a blogject has some utility conceptually, for us, it is one form of logging object in a much larger socio-technical ecology of logjects. We broadly define a logject as an object that monitors and records in some fashion its own use. More specifically, and expanding on Bleecker, it is (1) uniquely indexical, (2) has awareness of its environment and is able to respond to changes in that environment that are meaningful within its functional context, (3) traces and tracks its own usage in time and/or space, (4) records that history, (5) can communicate that history across a network for analysis and use by other agents (objects and people), (6) can use the data it produces to undertake what Dodge and Kitchin (2007a) term 'automated management' – automated, automatic and autonomous decisions and actions in the world without human oversight and to effect change through the 'consequences of their assertions' (Bleecker 2006: 9); and (7) is programmable and thus mutable to some degree (that is, it is possible to adjust settings, update parameters and to download new firmware[6]). Logjects then enable the kinds of unobtrusive machine-to-machine, machine-to-person and person-to-machine exchanges that are a fundamental trait of pervasive computing and are diverse in their nature. We can identify two main classes of logject: impermeable and permeable.

(i) Impermeable logjects:

Impermeable logjects consist of relatively self-contained units such as a MP3 player, a PDA or satnav. Such devices trace and track their usage by default, recording this data as an embedded history; are programmable in terms of configurable settings and creating lists (e.g. play lists of songs, diary entries and route itineraries); perform operations in automated, automatic and autonomous ways; and engender socially meaningful acts such as entertaining, remember an important meeting and helping not to get lost. These devices also work to relieve the cognitive burden of routine tasks and help to reduce the risks and consequence of unexpected events. Unlike a permeable logject all essential capacities are held locally and primary functionality does not require network connection to operate. That said, data (e.g. music, diary entries or map files) and software must be downloaded onto the machine at some point and the GPS works by receiving (though not exchanging) radio signals from satellites. Moreover, these devices can be connected to wider networks and information can be uploaded and exchanged with other devices (via Bluetooth wireless transmission, for example) and updates in firmware downloaded, though typically this is not automatic and sometimes requires considerable human intervention (what might be classed 'digital housework', e.g. syncing a PDA or MP3 player). The uploaded information can be processed and analysed in relation to other usage thus providing added value. The aggregate social significance of such objects is impossible to estimate but they are used to solve all manner of domestic problems billions of times a day.

(ii) Permeable logjects:

Permeable logjects do not function without continuous access to other technologies and networks. In particular, because they need the constant two-way of data exchanges, they are reliant on access to a distributed communication network to perform their primary function. Such logjects track, trace and record their usage locally but because of memory issues, the necessity of service monitoring/billing, and in some cases a user's ability to erase or reprogram such objects, their full histories are also recorded externally to its immediate material form. Some permeable logjects are relatively fixed in the environment (e.g., satellite/cable television control boxes, home security monitoring systems) and others are inherently mobile (mobile telephones, telematically monitored vehicles).

Permeable logjects are just beginning to become common in domestic settings, particularly for home entertainment. The television and VCR are iconic consumerist domestic objects, widely promoted and omnipresent in British homes. Over the past fifty years or so the television has become the dominant form of home entertainment and the set itself typically enjoys a prime location in the core space of most homes[7]. The nature of these objects are changing significantly, however, through a reconfiguring of their relations to the wider world as they shift from analogue broadcast and electronic controls to fully digital objects engaged in two-way networks. Digital television (with so called set-top box) offers interactivity and DVRs (digital video recorders, such as the Tivo or Sky+) have the capability to record television shows in much more flexible ways (e.g. software automatically skipping adverts is an oft-touted function). Importantly set-top boxes and DVRs log how they are being used, silently building up profiles of viewer habits and supposed preferences, offering opportunities to record future shows without being explicitly programmed to do so, as well as recording other shows deemed algorithmically to match owners viewing profiles. When these logjects become connected to the wider world through networks (usually a telephone line or cable) they become permeable with an ‘up’ channel to communicate profiles to outside organisations, typically large media corporations. As Carlson (2006: 111) notes, ‘[w]hile viewers enjoy the freedom to create personalized experiences based on preferences, their individual behaviors are monitored and assessed for their commercial value.’ The result is that the practice of television consumption is changing – code renders the television a two-way mirror that watches the viewers as the viewers watch it.

Mobile permeable logjects can access networks whilst on the move, predominately through a range of radio communication technologies (such as GSM, Wifi, Bluetooth). Like other permeable logjects they are reliant on the network connection to function, so for example a mobile phone will only work as a communication device where wireless coverage exists. The phone handset records locally the time and date of all incoming and outgoing calls and texts (and can store numbers to the local phone book), but such information is also recorded by the telephone service company along with ancillary data such as where the call occurred. Without human intervention, all the time a mobile phone is powered it is continuously polling nearby antennas to verify its connectivity. Thus the phone itself is able to respond automatically and autonomously when needed by its owner, reacting to incoming calls by sounding the ringtone, switching to the answer service if the call is unanswered, and alerting the owner that a call was missed and/or a message is waiting for them. Consequently, phone companies can approximately track the geographic location of all devices accessing network, and mobile phones have been described as a ‘spy in the pocket’ by Green and Smith (2002). Just like the television, they highlight the inherent and intimate surveillant potential of permeable logjects to reveal something of the nature of otherwise private domestic activities.

## Coded objects and the making of homes

> ‘As a space of belonging and alienation, intimacy and violence, desire and fear, the home is invested with meanings, emotions, experiences and relationships that lie at the heart of human life.’ (Blunt and Varley 2004: 3)

> ‘When it is not only “us” but also our “things” that can upload, download, disseminate and stream meaningful-making stuff, how does the way in which we occupy the physical world become different?’ (Bleecker 2006: 10)

Work across the social sciences documents how the home is a complex set of social and material relations (see Blunt and Dowling 2006; Hitchings 2004; Kaika 2004; Mallett 2004; Miller 2001) and a site of continual technological adoption. Home is a dwelling space in which important lived experiences take place providing a loci for the fundamental aspects of daily social reproduction (eating, personal care, relaxation and sleep, and so forth). Home is also central to human psychological well-being; a place of familial relations and emotional ties; a place for personal life and privacy from others; a place with layers of memories and meanings of past; a sanctuary which offers security and safety from the wider world[8]. Home is important then, not least because we spend most of our time 'at home'[9].

In contrast to static and teleological notions of a home, we would view the home as the product of a diverse range of relational and contingent processes. A great deal of emotional, physical and financial effort is expended in the maintenance of the physical dwelling along with the nurturing of home life. A significant part of this work in creating a 'proper' home involves the continual ordering of time, spaces and resources into configurations to solve ongoing problems of living. To facilitate the orderings and routines of home-making a plethora of technologies are used. Indeed, Western homes function through the use of products, tools, machines, gadgets and equipment - from toothbrushes to door locks. Homes are meta-machines of literally thousands of different technological components.

Our contention is, as we have detailed above, that the nature of some these material technologies in terms of everyday objects are changing as they increasingly become infused with software. Domestic objects are gaining capacities that extend their technicity and enable them to do additional work in the world. Indeed, it seems likely that most objects that currently use electrical power will become colonialised by computer code in the (near) future, just as a wide range of manual and mechanical household tools became newly animated by development and integration of electrical motors in the first half of the twentieth century (Cowan 1983). These capacities we argue are helping to reshape domestic living and its spatialities by on the one hand augmenting and supplementing domestic tasks, and on the other plugging the home into new, extended, distributed networks. In other words, coded objects are reconfiguring the social and material relations of home, often in banal and subtle ways (in much the same way as the electric motor in earlier rounds of technological domestication). They do so, we argue, because they transduce space; that is they beckon new spaces and spatialities into being through their actions. Coded objects make anew a domain, such as a home, in reiterative and transformative practices through the work that they perform (Mackenzie 2003). Significantly, they can do this without human oversight by processing information they have generated or received and determining courses of action.

As detailed by Dodge and Kitchin (2004), coded objects beckon two particular forms of space into being – code/space and coded space. Code/spaces are spaces dependent on software to function; that is the relationship is dyadic. Without software-enabled technologies the space would not be produced as intended. For example, a home office that requires an internet connection to enable a person to check email and work on files remotely is dependent on code to produce the intended spatiality. If the computer or the internet connection 'fails' then the space fails to be a remotely-extended home office. Coded space is a spatial transduction that is mediated by coded processes, but whose relationship is not dyadic. In other words, software enabled technologies produce particular spatialities, but if they are not present or operative a space is still produced as intended but less efficiently or cost-effectively. For example, if a digitally controlled burglar system fails, the house is still a secure home, albeit a less safe one than hoped. Most digital objects in a household transduce a home as coded space – that is they make a difference to how the space is transduced, but they are not essential to the majority of domestic tasks and the function of most rooms (there are alternative means of solving domestic problems by configuring resources and home spaces in necessary ways such as for cooking and cleaning, childcare and providing entertainment).

Here, we are interested in coded objects in the home, some of which are networked, but it should also be noted that home is represented and worked upon by a wide range of coded processes external to the household (see also Dodge and Kitchin 2005a). Consumer and governmental instruments of measurement, surveillance and classification, concerning, for example, personal finances, insurance, taxation, utilities, and benefits, envelope households in multiple, overlapping grids of calculation; nearly all of which is now undertaken using databases and processed automatically by software algorithms (cf. Graham 2005; Lyon 2002). In the case of geodemographic representations homes are ‘sorted’ according to perceived value or risk which determine which services are offered to them (cf. Goss 1995; Curry 1997).

## Home coding vignettes

To illustrate our taxonomy and argument so far, in this section we document coded objects from three ‘typical’ British homes. These vignettes are based on broad observation of different homes, but should be acknowledged as being fictional. Their aim is purely illustrative and, despite the anecdotal empiricism employed, we believe they highlight how coded objects are now commonly embedded in millions of homes and are widely used to solve a host of different domestic tasks. Of course, the vast majority of homes still possess many objects in analogue form, demonstrating that the transition to something approaching ‘pervasive computing’ occurs faster and slower depending on person, place and circumstance (cf. Rode 2006). In the vignettes, UCO refers to unitary coded object, IL refers to impermeable logject, and PL refers to permeable logject.

*Vignette one:*

| Household: Peter (aged 47), Wendy (aged 44) and three children | | | |
|---|---|---|---|
| *Demographics* | | *Dwelling*  | |
| *Social class* | 2. Lower managerial and professional occupations | *Age of dwelling* | 20 years |
| *Occupations* | Peter: regional sales manager; Wendy: school teacher | *Size of dwelling* | Semidetached three-bedroom, with additional attic room |
| *Annual income* | £50-55,000 pa | *Other features* | Single garage, front drive and rear garden with shed and greenhouse |
| *Children* | Joshua (14), Toby (9), Milly (1) | *Services and utilities* | Gas, electricity, water, telephone, cable television |

Peter, Wendy and their three children constitute a typical 'hard working family'. Both parents work full-time and they have a hectic home life raising the children and caring for pets. A range of technologies and an increasing number of coded objects are used in the daily production of their home creating a series of overlapping coded space and code/space, as a basic audit reveals.

*Living room*: The main family room is the focus of entertainment and information gathering, and an intense point of digital media use at different times of the day. Pride of place in the room is given over to a large flat-screen digital television (UCO) partnered with coterie of coded objects to provide it with apposite media sources. The family have recently upgraded from a separate analogue video recorder and DVD player to an integrated digital video recorder (IL). A Sky+ satellite decoder box (PL) is connected to the telephone line, necessary to access some of the more sophisticated interactive services, particularly pay-per-view sports enjoyed by Peter and his sons. The move to a

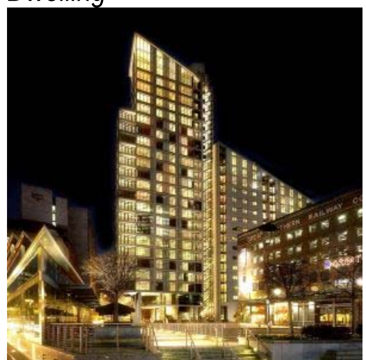
digital television system has increased range of viewing options and enhanced flexibility of schedules. Together the televisual assemblage works as a powerful permeable logject that 'watches' the family and communicates the log to their service provider.
One corner of the living room has been semi-permanently reconfigured to serve as a computing 'zone' for the main family desktop PC (along with printer, scanner and various 'connectors' for cameras, PDA and the like). It is permanently connected to the internet via broadband and is the most obvious permeable logject in the home, revealing much of their domestic, online activities to their ISP (cf. Bennett 2001). At the moment the digital camcorder, an expensive and relatively little used impermeable logject, is on the table next to the PC. The living room also plays hosts to an Xbox360 video game console (IL), that can be connected to the internet (becoming a PL) and contains a multi-function cordless phone and answer machine that serves as main contact 'number' for the home but is being usurped increasingly by flexibility offered by individual family member's own mobile phones (PLs).

*Kitchen-diner*: Along with the living room, the kitchen is typically the busiest room in the house serving various home functions such as preparing food, cooking, washing, ironing, and socialising, etc. These functions are often aided by domestic appliances, many new models of which are now augmented by code. In Peter and Wendy's case, most of their appliances are more than five years old and are analogue in nature: cooker/hob, microwave, dish washer, fridge-freezer and tumble dryer. As such they are uncoded objects, but are likely to become coded objects when next replaced. This has occurred with respect to the washing machine (UCO), which is a new model that offers a raft of software-driven programmes and options from its LED control panel. While the software potentially makes a difference to the wash, in this case the family typically only uses a couple of preset programs so that the code makes little, if any difference, to the household's laundry practices. In one corner of the kitchen is the control panel for the central heating (UCO), which was recently updated following the replacement of the boiler. The control is code driven, notionally providing much greater control over heating (timings and temperature level), with settings held in rudimentary database.

*Bedrooms*: These rooms are typically more private spaces and less coded than the living room and kitchen. The master bedroom contains several pieces of home gym equipment that includes digital performance monitors (IL), used on a semi-regular basis by Peter. Joshua's attic bedroom contains a growing number of coded objects including a new laptop, a DVD player, MP3 player and speakers, digital camera and an aging games console (all IL unless consciously networked). The room also has other media technologies including an analogue television and radio. Toby's bedroom has a large range of toys, some of which use electronics and software to provide interactive features (UCOs). The last bedroom is operating a specialised space at present, serving as a nursery for baby Milly and contains a baby monitor and electronic learning toys which often are controlled by software (UCO).

*Bathroom*: The family bathroom is the most private space in the home and also the least mediated by electrical and electronic powered technologies. Yet it is a highly technological space, one that is dominated by machines to safely channel water and remove waste efficiently. As a pivotal space for personal care of the body it has several portable coded objects, including Peter's pedometer (PL) and Wendy's digital 'body monitoring' weighing scales (PL), both impermeable logjects.

*Vignette two:*

| | | | |
|---|---|---|---|
| Household: Simon (aged 43) and Iris (aged 37) | | | |
| *Demographics* | | *Dwelling*  | |
| *Social class* | 1. Higher managerial and professional occupations (Large employers and higher managerial occupations) | *Age of dwelling* | 1 year |
| *Occupations* | Simon: solicitor; Iris: personnel manager | *Size of dwelling* | Three-bedroom apartment |
| *Annual income* | £85-90,000 pa | *Other features* | Security gates, CCTV cameras and secure parking and shared access to managed garden area. Fire and smoke alarm. |
| *Children* | None | *Services and utilities* | Gas, electricity, water/sewage broadband, cable television |

Simon and Iris are both full-time, professional workers with no children or pets. They have high disposable income, are technologically savvy, time-pressured, and security conscious. They regularly work at home as part of their lifestyle.

*Living room*: The living room contains a variety of very expensive, branded home entertainment technologies (all are coded objects). A large high-definition plasma screen television (UCO) is mounted on one wall, linked to a home theatre amplifier and surround sound speakers. It is also connected to a cable television set-top box (PL), a DVR (PL) and to a Slingbox (PL), a wireless networking device that distributes the digital television signal into other rooms of the apartment. Simon is something of music aficionado and the room has a state-of-the-art hi-fi system which is heavily coded but is not logging usage or networked. On the table is a year old Apple MacBook laptop (PL) that Iris and Simon use as a home PC for surfing the web, including online grocery shopping; it is always networked via wifi to the household cable broadband. On the mantel piece are two Kodak Easyshare digital picture frames (UCO) showing a sequence of photographs from their summer holiday in New Zealand. They have no fixed line telephone, using the cable broadband for wifi and VOIP calls (using Skype software) and have multiple mobile phones (for work and personal).

*Kitchen:* The space is purposefully designed as a 'luxury' fitted kitchen with top of the range appliances and built in media centre (LCD television and DVD player) all of which are unitary coded objects and are programmable in some way. The kitchen also has a DAB radio (UCO), although the addition of software make little difference to Iris' radio listening whilst cooking. On one wall is a LCD panel that provides software interface to control the environmental system (PL) for the apartment which offers individual room heating and air conditioning profiles, along with wireless connection and remote online access. In a cupboard, next to the vacuum cleaner, is a redundant gadget that Simon bought for Iris as a present (Figure 1). This robotic convenience has only been a used a couple of times as they pay a cleaner to come in and clean the apartment two mornings a week.

*Bedrooms:* Their main bedroom has little coded technology except for an alarm clock-radio (UCO) and a LCD digital television and Slingbox receiver for cable television signal (IL). The room is also a transitory site for various mobile coded objects (such as phones, PDAs, laptops, MP3 players) at different times. The second bedroom of the apartment is permanently configured as a home office and contains a range of computers and associated paraphernalia to support Simon and Iris when they want to work from home. There is a new desktop PC and an aging iMac (both PL) along with a laptop docking station and monitor (UCO), plus a cradle for a PDA and a iPod (UCO). On top of one of the monitors is a webcam (PL) that Simon occasionally uses. Under the desk is a wireless router for cable broadband (PL) that provides secure wifi networking throughout the apartment; also hidden away there is a redundant fax machine (UCO) fully replaced by the PC and now inoperable as the apartment does not have a conventional landline phone connection. The bottom of a filing cabinet also contains several generations of digitals cameras (UCO), a camcorder (IL), a couple of redundant mobile phones (IL) and media players (IL), and an external hard disk (IL) for infrequently-made backups of their growing range of personal data. On top of the filing cabinet is a wireless colour laser printer (PL). Lastly the office is the storing place for Simon's large digital keyboard synthesiser (IL).

*Entrance hallway*: Next to the front door of the apartment is a video entry phone (UCO) that allows them to control entry to the apartment block. Nearby is the control panel for the apartment's burglar alarm that is connected to central monitoring station. (There are four movement sensors in different points in the apartment, along with the sensors on several windows that are potentially vulnerable). The storage cupboard in the hallway also contains two 'smart meters' (IL) recording the household's utility usage.

*Vignette three:*

| Household: Dorothy (85), widowed | | | |
|---|---|---|---|
| *Demographics* | | *Dwelling* |  |
| *Social class* | N/A. | *Age of dwelling* | 78 year |
| *Occupation* | Retired | *Size of dwelling* | Two-bedroom terrace |
| *Annual income* | £10-15,000 pa | *Other features* | |
| *Children* | Three (grown-up) | *Services and utilities* | Gas, electricity, water/sewage, telephone |

Dorothy has lived in the same house for over forty years and has been a widow for eight years. She is still relatively active and enjoys visits from her grandchildren, but she has a growing number of medical problems that have reduced her mobility. She has come to rely on homecare and assistive, ‘quality of life’ technologies and tele-monitoring to keep her living independently, but much of her house is uncoded.

*Living room*: In the living room there is a range of home entertainment technologies including a television and VCR along with a radio-CD player (all electronic rather than coded). From television adverts Dorothy is aware that a ‘digital switch over’ (the turning off of analogue television broadcasts) which means she will need to update her television set but is worried about costs and uncertain over the details of what she will need to do. There is a cordless digital telephone base station (UCO) on the coffee table and Dorothy usually takes the handset with her as she moves about the house during the day otherwise she risks missing phone calls. She has no mobile phone. The living room also contains the Lifeline control box for the telecare home monitoring system (PL) that unobtrusively ‘watches’ Dorothy’s daily activities and provides a safety net for summoning help if she has a fall in the house. This boxes is permanently networked via a landline phone connection to a remote control centre. It is wired to PIR sensors in all rooms and several fixed panic alarms (including a pull cord in the bathroom) and the pendant alarm that Dorothy wears.

*Kitchen:* The kitchen contains a range of old appliances, none of which are coded but which remain perfectly functional. The central heating control is an old 'clockwork' timer with a manual thermostat. There is a new DAB radio (christmas present) on the kitchen counter but it is permanently tuned into Dorothy's favourite local station and its additional functionality ignored. The day's post lies on a counter including a bulky padded envelope containing her repeat prescription of tablets ordered automatically for her by a health management database at the local pharmacy. The post also contains a couple of pieces of junk mail calculated by the geodemographic profile for this postcode to appeal the householders but quite inappropriate for Dorothy's lifestyle. Dorothy's home and domestic activities, relatively uncoded at the immediate scale of the dwelling, are nonetheless still represented and automatically worked-upon by code at various distant sites.

*Bedroom and bathroom:* These rooms have no coded objects beyond the PIR movement sensors on the wall, a panic alarm button/cord and a bed occupancy sensor - a pressure pad under the mattress (UCO).

**Pervasive computing and the promise of the 'home of the future'**

The vignettes highlight that there are diverse kinds of coded objects already embedded within Western homes. For many technologists, this is evidence that we are moving to the era of the 'smart home' and widespread pervasive computing. Pervasive computing, as defined by Galloway (2004, 384-5), 'seeks to embed computers into our everyday lives in such ways as to render them invisible and allow them to be taken for granted.' The aim of its advocates is to augment all aspects of everyday life and activities through the addition of computing power to objects and spaces, rendering them smart to some degree, yet also mundane and routine (Dodge and Kitchin 2007b).

Given the growing range of digital technologies and software in the home, it is not surprising that within pervasive computing research the domestic sphere is a target of much investigation and speculation (cf. Bell and Dourish 2007; Crabtree et al. 2003; Edwards and Grinter 2001; Taylor and Swan 2005). There is a belief that, as Galloway (2004) argues, computers can be brought wholesale into our home worlds then domestic practices can be radically altered. A central trope in such research is the notion of a home that ‘anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond’ (Aldrich 2003: 17). Such anticipation and response will be fully automated, automatic, autonomous, decided upon by sophisticated software algorithms designed to be reflexive to home users desires and wishes. This is the vision of the ‘smart home’ – a home with computing power built into all the objects contained within; a home that is aware of itself and its past activity, its surroundings, its inhabitants, its contents, and its external service providers, and knows how to react appropriately to different scenarios. This vision anticipates computing power to be built not just into objects within the home but also the fabric of the dwelling itself.

With respect to coded objects in particular, some in the pervasive computing community presently envisage their logical end point as, what the science fiction writer turned technological futurist Bruce Sterling (2005) has termed, spimes. A spime is a wholly new kind object for which there is an entire recorded history stretching from manufacture to disposal. Such histories will include ‘deep’ details on (1) everything used to make, process, distribute that object, plus protocols for safe and sustainable disposal, (2) everyone/everything that has come into contact with that thing during its life-time, (3) the context of making and use – labour relations, cost and profit margin, carbon tax, patents. In other words a spime is an object that has a full genealogy wherein the entire actor-network of a thing is knowable and indexical, which, Sterling (2005: 11) asserts, means they are ‘material instantiations of an immaterial system ... [they] begin and end as data’.

Although no spimes presently exist, there are projects and programmes that are developing what might be might be termed proto-spimes; that is they invest objects with spime-like capacity although their capacities exist external to the thing being recorded. For example, there have been a number of projects to make transparent the full extent of food production (cf. Popper 2007). With respect to agriculture these are moving beyond existing ‘farm-to-fork’ tracking systems to much more granular tracing that aim to follow livestock from conception (i.e., recording both parents and over time the lineage of all animals and how they were reared) to the consumer’s home (through farms, abattoirs, logistics chains and supermarkets). A smart home would consist of an assemblage of computationally rich building fabric and spimes.

While it is possible to argue that we are on the path to such an assemblage, it must also be recognized that smart homes are a particular socio-technical vision developed by technologists; the latest re-incarnation of a long-running modernist fantasy of technology capable of producing orderly domestic spaces and maximising leisure time (Figure 1; cf. Corn and Horrigan 1984). Indeed, the premise of a smart home has been common across several generations of home design (Spigel 2005), promulgated by a nexus of designers, house builders and appliance manufacturers and increasingly the software industry focused on driving new rounds of consumer fashions and home ‘upgrades’.

The domestication of software also clearly has a variety of potential social implications. Perhaps the most obvious is the scope for greater control of mundane and personal activities occurring in the home and a concomitant impact on freedom and privacy. This control by code will vary from subtle, almost voluntarist, conditioning that is little noticed, such as the pre-selection of potentially interesting programmes to watch by a television, or ‘body monitoring’ bathroom scales chiding its user for missing their target weight and urging greater efforts of performance (cf. Schuurman 2004) to a more potent form where coded objects refuse to perform because they determine that an action in ‘illegal’ (for example, copyright enforcement through digital right management stopping the computer playing movies not legally owned; see Dodge and Kitchin 2005b, Graham 2005 and Lyon 2002 for a fuller discussion on surveillance and control).

Yet, control is not the whole story. At the same time code opens up genuinely novel avenues for creative solutions to domestic tasks particularly in terms of pleasure and play. How software can make things differently is well illustrated by new children’s toys and games. Indeed, creating fun is an important conduit through which software is seeping deeper into the sinews of home life, as Thrift (2003: 400) notes toys are ‘rapidly becoming something else: something between a lumpen object onto which all manner of fantasies and all kinds of play could be projected and a kind of alternative life form, participating in the world on at least some terms of its own choosing.'

In addition to the spectre of control and empowerment of creativity, the enrolment of code on a wide scale into the home brings with it a whole new layer of complexity and risks to daily living, despite the rhetoric of software making life easier. A foretaste of this complexity is the real cognitive work required in maintaining home PCs and mobile devices in proper order. It is estimated that several million compromised home PCs are presently connected to the internet (Leyden 2005), in large part because their owners are technically unable or unwilling to invest time to keep them secure and patched with updated software and to keep passwords secret. As more and more objects become permeable it will become increasingly important to maintain them. The result will be the development of a whole new domain of 'digital housekeeping' (Crabtree et al. 2007) to keep software-driven appliances stable and secure.

The complexity of code will also be felt in the form of excessive functionality, where a previously simple task achieved with straightforward dials and switches becomes overwhelmed by menus, options and check-boxes on screen. It is likely that many people will simply fall back on default settings that 'seem to work', a point echoed with earlier rounds of 'complex' electronic home technology like the VCR where large numbers of people failed to be able to program them successfully and simply used them as basic playback devices (cf. Rode et al. 2004). Greater complexity also entails risks particularly where coded objects become the primary (and perhaps only) store of information that is valuable to owners (such as financial details or sentimentally valuable photographs). The risks on relying on software to keep these digital media safe is compounded because people are often poor at maintaining backups (a very tedious piece of digital housekeeping), and where the coded object becomes permeable these media could be accessed and stolen remotely.

Given these various issues there will, almost certainly, be some populations who actively resist the encroachment of software into the home concerned by the potential for surveillance by outside parties, along with those who will 'hack' the code to subvert the deadweight of 'technological paternalism' (Spiekermann and Pallas 2006) and those who will voice objections because of the frustration caused by function overload and software-induced excessive complexity.

The extent then to which ‘smart homes’, as envisaged by technologists, will come to fruition is doubtful. While there is no doubt that code is increasingly becoming part of everyday homes and does make a difference to how homes are produced, as illustrated by our vignettes, any transition to the era of the ‘smart home’ will take place over a very long period of time. With respect to the adoption of coded objects, many homes continue to contain analogue objects that will in many cases be used until they need to be replaced. In other cases, coded objects are expensive, luxury items that require a certain income, lifestyle and technical literacy to purchase and operate. With respect to the development of computationally rich building fabric this will require extensive and expensive retrofitting of existing buildings that is unlikely to be untaken without significant benefits to the home dweller or external regulatory pressure (such as requirements of mortgage lenders/insurers or waste/energy reduction in the name of more sustainable living). At present, it is unlikely that such adaptations will offer such tempting benefits especially with the rapid redundancy that currently accompanies technological change. As with the take up of any set of technological innovations then, the adoption of coded objects into the home will be uneven and unequal both socially and geographically, dependent on person, place and circumstance.

## Conclusion

In this paper we have argued that everyday objects are increasingly becoming coded and folded into the ‘internet of things’. To start to make sense of the diverse range of coded objects that are starting to become common in society we first provided a taxonomy of coded objects based on their relational capacities. Unitary objects rely on code to function but cannot keep a record their work in the world for future use. Logjects have an ‘awareness’ of themselves and their relations with the world and automatically record aspects of those relations in ways that can inform future activity. We identified two kinds of logjects: impermeable logjects are functionally self-contained units that work and log their use independently of any wider network; and permeable logjects that do not function without continuous access to other technologies and networks.

We then argued that these three types of coded objects make homes differently. Often working in autonomous ways, coded objects transduce into being different spatial formations – coded space and code/space. While the transduction of code/space is often rare in domestic settings, code is certainly central to how many domestic tasks are now performed, with the transduction of coded spaces extremely common. In other words, the everyday use of coded objects reshapes the spatiality of the home by altering how domestic tasks are undertaken (and not always more conveniently for all), introducing new tasks and sometimes greater complexity, and embedding the home in diverse, extended networks of consumption and governmentality.

To illustrate our argument we examined three 'typical' British homes. These homes revealed that a diverse range of coded objects are already present within all the spaces of the home. In some cases these coded objects have already become mundane and slipped into the background 'technological unconscious' (Thrift 2004), and yet they perform vital roles in holding together household routines. Arguably, in the Dorothy's case the monitoring of her by coded objects and software algorithms insures a greater degree of safe living, that in combination with other supports, means she can remain in her own home. In other cases, the coded objects are seen as novel and are feted as technological breakthroughs that provide new ways of being and acting. Indeed, many homes now contain multiple iterations of the same appliances (particularly those for entertainment), along with older and superseded versions (rendered obsolete by new functionality or mere changes in consumer fashion). Some others are perhaps little more than gimmicks, such as continued attempts to provide robotic solutions to domestic drudgery (Figure 1).

As we have documented, the transition into the fully software-enabled home is a slow process. Most homes contain a mix of non-coded and coded technologies. We are confident, however, that we are at a juncture in the nature of home space, as domestic objects become more and more coded – either through software being embedded into their make-up or as machine-readable objects embedded in the Internet of Things. Here, we would argue that a useful parallel can be drawn between the coding of homes and the initial development of domestic electricity. At first, there were no electrical appliances and whole classes of electrical tools had to be invented. Over an extended period of time existing technologies were converted to electricity (e.g. gas lights to electric lights, open hearth to electric cooker, washtub to washing machine, etc.). Today, the extent to which electricity powers almost everything of significance in our homes is largely unnoticed in a Western context (except in a power cut).

Our belief is that code will have a similar impact as electricity, driving technologies that work in both the foreground and background to shape domestic living and spatiality in all kinds of unconscious ways. As such, we feel that coded objects demand further attention as key, future actants. While we have made a start in this article to sketch out their emerging forms and the work that they perform in the world, over time, there will be a need to more fully examine their nature from an ontological and epistemological point of view and to tease out the difference they make across a number of domains such as home, work and public space and to fundamental spatial processes such as communication and travel. For us this will need to entail the construction of detailed ethnographies of the development, use and networking of different kinds of coded objects; how they are placed into and become key actants in complex actor-networks; and they work in diverse conjunctions with people to realize a multiplicity of spaces and spatialities.

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Table 1: Hotpoint washer-dryer error codes that are displayed by software to the user. These codes give a partial indicator of the range of conditions that the appliance's software monitors. (Source: Hotpoint Service website – Help Centre, 9 November 2007 <http://www.hotpointservice.co.uk/hs/pages/content.do?keys=FAQ:ERROR_CODES>.)

Fault codes for LCD EVO1 Washing Machines and Washer Dryers

* F01 - Short circuit motor triac - Book a service engineer.
* F02 - Motor jammed tacho detached - Book a service engineer.
* F03 - Wash thermistor open/short circuit - Book a service engineer.
* F04 - Pressure switch jammed on empty - Book a service engineer.
* F05 - Pressure switch jammed on full - Book a service engineer.
* F06 - Program selector error - Book a service engineer.
* F07 - Heater relay stuck - Book a service engineer.
* F08 - Heater relay cannot be activated - Book a service engineer.
* F09 - Incompatible eeprom - Book a service engineer.
* F10 - Pressure switch not sensing correctly - Book a service engineer.
* F11 - Pump cannot be activated - Book a service engineer.
* F12 - Communication error - Book a service engineer.
* F13 - Dryer fan or dryer thermisotor faulty - Book a service engineer.
* F14 - Dryer element faulty - Book a service engineer.
* F15 - Dryer element relay faulty - Book a service engineer.
* H20 - Not fillings. Check tap, hose and inlet valves
* LOCKED - Check interlock - Book a service engineer.


Figure 1: Magazine advertisement for domestic coded object that promises greater convenience through automation. (Source: *Guardian weekend magazine*, 20 October 2007, page 34.)

[1] Enrolment in the internet of things, using technologies of RFID tags and electronic product code (EPC) databases, makes objects uniquely identifiable, inherently trackable and potentially communicative of their status across distributed networks. In much the same way that the location of a website can be 'looked-up' through its unique domain name from anywhere on the Internet, it is envisaged that the 'internet of things' will facilitate the same for any tagged object. It is essentially a universal indexing mechanism for anything and everything that matters and a mechanism by which objects can connect to, transfer and process information with each other and people (cf. Dodge and Kitchin 2005b).

[2] For example, the ubiquitous 12 digit Universal Product Code (UPC) system found on retail products.

[3] We have adapted the term logjects from Bleecker's (2006) more narrowly conceived notion of blogjects. For us, blogjects are one class of logject.

[4] A charge coupled device (CCD) sensor converts light into electrical charge. At the edge of the CCD sensor an analogue-to-digital converter transforms the electrical charge into a digital form.

[5] Analogous to a conventional blog wherein the owner posts ideas, thoughts, opinions, information, questions, and so on to a website that other people can comment on. A blog is more than simply a personal webpage because it requires continual (daily) posting activity and it acts as a site of social exchange where information is generated and communicated through both broadcast and dialogue. Over time a searchable history of all exchanges is created.

[6] Software embedded onto the microprocessor to provide low level control functions for the hardware.

[7] Penetration in British homes of television sets was ninety-nine percent and VCR was eighty-nine percent in 2002 (ONS 2004: 49). The 2005 Time Use survey found that on average 157 minutes per day were spent watching televisions and videos/DVDs or listening to music and radio (ONS 2006: 11). Television ownership is also intensely monitored in the UK because of the mandatory payment of annual license.

[8] Although not for all, as illustrated by the extent of domestic violence (cf. Warrington 2001).

[9] According to the 2005 Time Use survey, on average people in the Great Britain spend 70% of their time at home (ONS 2006). Around of third of this time is spent sleeping.