A Day in the Life of Things in the Home

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ABSTRACT
This paper is about human interaction with things in the home. It is of potential relevance to developers of the Internet of Things (IoT), but it is not a technological paper. Rather, it presents a preliminary observational study of a day in a life of things in the home. The study was done out of curiosity - to see, given the emphasis on 'things' in the IoT, what mundane interaction with things looks like and is about. The results draw attention to the sheer scale of interaction with things, key areas of domestic activity in which interaction is embedded, and what it is about domestic life that gives data about interaction its sense. Each of these issues raises possibilities and challenges for IoT development in the home.

Author Keywords
Ethnography, domestic environment, mundane interaction with things, Internet of Things.

ACM Classification Keywords
J.4 Computer Applications - Social and Behavioural Sciences: *Sociology*.

INTRODUCTION

> "Until quite recently, the development of smart homes … seemed appealing and immanent … Be that as it may, those working within the smart home agenda … found themselves oddly side-stepped by the world at large. For homes have altered in ways that have largely passed them by … All of us are familiar with these changes … They are now so ubiquitous as to be commonplace: wi-fi networks are now the norm …. We are all used to plugging into the internet on our couches, even in bed … **the connected home** is manifesting this new emphasis" [16]

The shift from the smart home to the connected home is today marked by renewed interest in the purposing of ubiquitous computing technologies under the auspices of the Internet of Things (IoT). The vision is less about wholesale intelligent homes and more about embedding networked computing in mundane objects to deliver new applications and services to the connected home, largely through the harvesting of personal data [14]. The ACM and IEEE archives make it clear that a great deal of technical work is being done on IoT infrastructures and application areas, and this is complemented by a broad range of products coming onto the market [e.g., 1].

This study complements but departs from studies of interaction with digital things in the connected home, as exemplified by [16], to take a broad range of non-digital things into account as well. It does so because the IoT suggests that computing can be embedded in just about *any thing*, and looking beyond what has currently been made digital might therefore be useful. We are not, of course, the first to study interaction with non-digital things in a bid to inform design for the home, though the studies that do exist focus (like their digital counterparts) on specific categories of thing (e.g., mail [15], mementoes [25], messiness [31], etc.). We take a different tack here, shifting from an in-depth look at specific things in the home to a broader perspective on things from the point of view of *a day in the life of mundane interaction* with them.

This shift does not represent a critique of prior studies. To reiterate: the study reported here *complements* prior work, extending ethnomethodological studies of domestic life and the 'artful' [33] ways in which the 'domestic routine' [6] is *assembled* as an 'unremarkable' [34] feature of the locally accomplished social order. The extension, and contribution to the literature, involves making visible the methodical assemblage of things as a *pervasive* feature of the accomplishment of the local order. This phenomenon is pointed to in the studies referenced above in, for example, the management of domestic work [33] or the handling of mail [15], but it is not treated as a topic in its own right and so remains implicit; a matter we return to in conclusion.

Our study is exploratory and preliminary in nature, a first pass through, opening up the *methodical assemblage of things* as a design topic and matter for further study and technical investigation. A first pass through reveals distinct *categories* of things and *patterns* of human-thing interaction, most of which have not yet been touched *directly* by digital technologies, and distinct *interactional zones* where particular categories of things *cluster* together. These findings relate to and further elaborate previous work in ubiquitous computing focusing on the 'stuff' of the home [26] and the how it coalesces within 'ecological habitats' and 'activity centres' [5]. The real world, real time coherence of these patterns and clusters is provided through the methodical assemblage of things as household members go about the business of locally ordering domestic life.

METHODOLOGY

The study we report here involves observations of mundane interaction in 2 ostensibly middle class homes in the UK, each containing 2 adults and one child. The homes are our own, partly chosen for expediency's sake but also to make doing the fieldwork tractable: our aim was to study interaction over a 24-hour period throughout the home. A great deal of personal data, and indeed very sensitive data, would therefore be gathered. Working on Sacks' [29] methodological maxim "tap into whomsoever, wheresoever and you find the much the same things" we figured we would be able to learn as much from our homes on a first pass through as from someone else's.

It is important to appreciate something of Sacks' work to appreciate what we are driving at here and to avoid any misunderstanding that we are suggesting that all homes are like ours. That would be a mistake. Clearly an impoverished immigrant household or a household in an entirely different part of the world (e.g., rural India) would look very different to ours in terms of the material resources to hand, daily rhythms and routines, situated practices and reasoning, etc. The equivalence does not lie in *what* the home looks like however, but in *how* the local order is brought about. Sacks' work is instructive in this respect.

Sacks' studies of conversation in everyday life identified a 'machinery of interaction' [29] whereby talk is locally ordered. This machinery is 'context and cohort independent' [28], which is to say it does not matter *where* the talk takes place or *who* is doing it. The machinery is used by anyone, anywhere, to order talk 'here and now' on any occasion of its occurrence. Sacks was not wedded to conversation – it just happened to be the material he had to hand [29] – and so the point of the maxim is that we might examine the various modalities of interaction (verbal, embodied, material, digital, etc.) to find some machinery of interaction whereby *order* is locally produced.

The equivalence, then, is not to be found in the type of household as it were, but in the machineries of interaction household members employ to produce local order in bringing about their everyday lives, wherever it occurs and whatever their lives. Thus, in looking at our homes, we are looking for some machinery of interaction implicated in the production of local order. Just as conversation is infinite in its use, what you see in our homes when looking at a day in the life of things is a machinery at work in producing *our local orders* of domestic life. Other homes may well look different, but the same machinery will be at work, i.e., the methodological assemblage of things as a constituent feature of accomplishing the local order.

It is not the application of the machinery that interests us per se then, though the unique order of domestic life in any particular home is of relevance to design as we will touch upon later. What concerns us here is surfacing the machinery of interaction or 'uncovering the animal hiding in the foliage' as ethnomethodology's founder, Harold Garfinkel, put it [12]. This aphorism hints at the commonplaceness of machineries of interaction, that they are seen but unnoticed or taken for granted and so blur into the background of everyday life. Our job here us to tease the animal out of hiding.

To this end we approached data gathering on the basis that *any* interaction with *any* thing – whether it be digital or physical – would be noted. So, for example, we would not just note that we interacted with bread but the whole set of interactions involved in getting it out of the bread bin, putting it on the chopping board, getting a knife from a drawer, cutting slices, etc. One of us did the noting with an audio recorder, the other on video. In either case, the aim was to articulate and document what we were doing, where, and with just what things. While centred on ourselves and what we did, data gathering involved our families because much of what we do at home inevitably involves our family members (they even operated the data recorders on occasion when our hands were full).

We did not gather the data over a 24-hour period. It soon became apparent that articulating the things you are interacting with is enormously difficult to sustain for a prolonged period, so we spread the study across a week in November 2014 breaking it into 3 and 4-hour sections and gathering data on a daily basis. It is worth pointing out the highly disruptive and intrusive nature of this exercise. Walking around the home articulating the specific things being interacted with by yourself and others for several hours each day soon became deeply irritating for household members, which presents real challenges for similar studies in other people's homes.

More serious, however, is the degree of intrusiveness involved in doing such a study. We looked at anything that was happening and we mean *any* thing during the recording periods, and we were called to account for doing so on occasion even by our own family members. "Do you really need to record this!" was uttered more than once and reasons had to be given for data recording to proceed, e.g., "Please, it's for science." Risible as this may be there is a serious point here about the *accountability* of such intrusive data gathering in the home, and there may well be something in that for IoT developers to consider as they won't get away with it as easily as we did (extremely good reason *will be* required for intrusive data harvesting).

STUDY FINDINGS

After capturing the data we created a report organised in terms of time, location (e.g., bedroom, bathroom, hallway), and activity being done and worked our way through the recordings describing the things interacted with as a feature of doing the activity. We then colour-coded things to reflect different categories of things, as this seemed a reasonable way of managing the enormity of things used in our activities. The categories were drawn from common usage in everyday life, particularly retail categories as these allowed us to put things into recognisable families or sets:

- Appliances (**APP**)
- Clothes and Soft Furnishings (**CSF**)
- Communications (**COM**)
- Fast Moving Consumer Goods (**FMCG**)
- Furniture (**FUR**)
- Media and Media Equipment (**MME**)
- Services, Fixtures and Fittings (**SFF**)
- Toys (**TOY**)
- Utensils and Other Equipment (**UOE**) [1]

Having described our interactions with things we then manually counted a) how many things were interacted with, b) how many interactions with those things occurred overall, c) how many specific things belonged to each category, d) how many interactions occurred with specific things in a category, and e) how many interactions occurred per category. We then generated a series of graphs to represent the results.

Before we present the graphs it is important to note the limitations of this data. It is only *partial*. We only recorded interactions with things that we were party to – other activities also occurred during the recording periods, but a fieldworker can't be everywhere at once. Also, you get what you get on the day, and some routine interactions (e.g., phone or video calls) didn't occur at the time of recording. The counting of interactions is also *inaccurate*. Firstly, for reasons that we have already mentioned – that it is very difficult to actually describe all the things interacted with (try it and see). Secondly, because of the practicalities of counting – do you count turning a tap on or off as 1 or 2 interactions with a thing, for example, or opening and closing a drawer or door? The upshot is that the numbers presented below massively *underestimate* interactions with things over a 24-hour period; perhaps by as much as 50% depending on how they were counted.

Now the statistically minded are going to find this deeply unsatisfactory, but it needs to be taken seriously when we say we are *not doing statistics*. We are qualitative researchers and would urge critics to read [8] before assessing what is essentially an account of *situated action* by the methodological canons of quantitative research. To do otherwise would be to miss the work that the numbers do here. *They do not detail generalities*, but situational specifics in the 2 homes studied. In doing fieldwork, as [8] makes clear, generality is not built into sample size but the *orderliness* of situated action. The numbers are but an initial means of opening up for inspection 'the animal hiding in the foliage' of situated action [12], i.e., the *orderly features* it is possessed of. While each home is unique the orderliness of situated action is not merely to be found in the 2 homes studied, but is a *methodical* feature of interaction with things in the home more generally. This observation does not turn upon the numbers, the numbers are just a first step on the way towards seeing that and what it might mean for design.

A First Step Towards Uncovering the Animal

In home A we found that 228 individual things were interacted with in a 24-hour period; in home B 299. However, the *overall number of interactions* with things in homes A and B were 1991 and 2494 respectively; Figure 1 shows how this breaks down per category in home A. We present the data from home A here in graph form, and compare it with salient aspects of the data gathered in home B as we go along.[2]

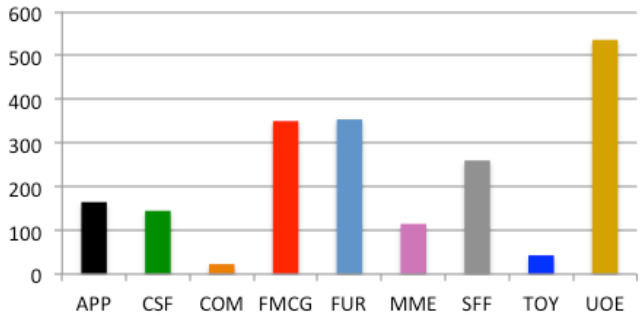

Fig 1. Overall number of interactions per category.

Interaction with Utensils and Other Equipment was top in both homes: 26.9% in home A and 22.2% in home B. Furniture came in 2nd in both homes (17.8% & 18.7% respectively). FMCG's were 3rd in home A (17.6%), Media and Media Equipment in home B (12.5%). 4th was Services, Fixtures and Fittings in both homes (13% & 11.7%). 5th was Appliances in home A (8.3%), FMCG's in home B (11.66%). 6th, clothes and soft furnishings in both homes (7.3% & 9.9%). 7th, Media and Media and Media Equipment in home A (5.8%), Appliances in home B (7.3%). 8th was Toys in home A (2.1%), which was replaced by Living Things in home B (3.6%). 9th was communications in both homes (1.2% & 2.4%).

Each category of thing, composed of multiple things, exhibits its own local patterns. 165 interactions with Appliances were recorded in home A (Fig.2), 183 in B. The bulk of these interactions were with computers (PCs, tablets, phones and peripherals) in both homes and involved

[1] While mundanely recognisable these categories are, as any such set of devices, open to (endless) revision [27]. We categorised computers as appliances insofar as a computer is a device and thus something that might ordinarily be defined as an appliance, for example, and email as communication insofar as this is what email is embedded in and achieves, but other categories could be developed for descriptive/analytic purposes. Insofar as there is any value to had from such categories here it lies in what they allow us show of interaction with things in the home.

[2] As we go through the graphs we will elaborate what kinds of things were being counted in each category. It is simply not feasible to list hundreds of items here.

such things as waking them up and logging in as a preface to other substantive interactions such as playing media. The cooker, fridge, and kettle were also prominent in both homes, along with lamps in home A. The oddity in Fig.3 is a drill, use of which was occasioned by the hanging of some pictures on a wall (not an everyday activity).

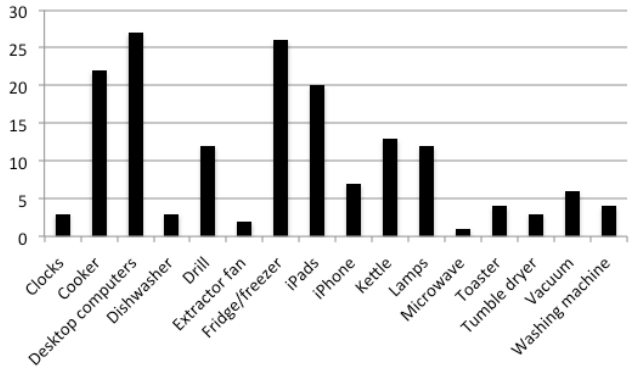

Fig 2. Interactions with appliances.

145 interactions were recorded with Clothes and Soft Furnishings in home A (Fig.3), 246 in home B. Clothes are by far the biggest kind of thing interacted with here, closely followed by towels (predominantly in hand-washing in bathrooms and kitchens). The rug also stands out in home A, being a site where a great deal of children's games occur, and curtains in home B, which are implicated in going into and out of the home.

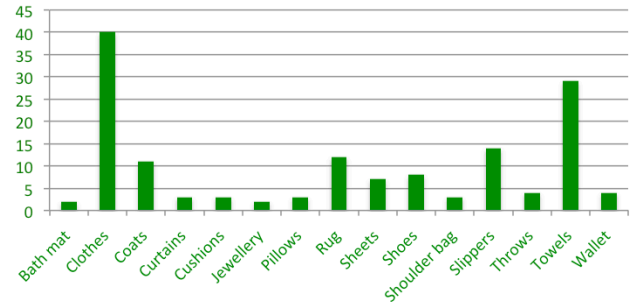

Fig 3. Interactions with clothes and soft furnishings.

Communications (Fig.4) was the least interacted with category of thing in our study, with only 23 interactions in home A and 60 in home B. As noted above, phone use and video messaging, both routine occurrences in homes A and B, were not captured during the study period. Had they been, they would not have made a significant difference to this result; it would still be the least interacted with category of thing. Email was by far the biggest category of communication in both homes. Paper mail came in second in home A and third in home B, where it was topped by social media (with 0.6% of interactions overall). Text messages and other online communications (such as meter readings or shopping orders) made up the remaining interactions.

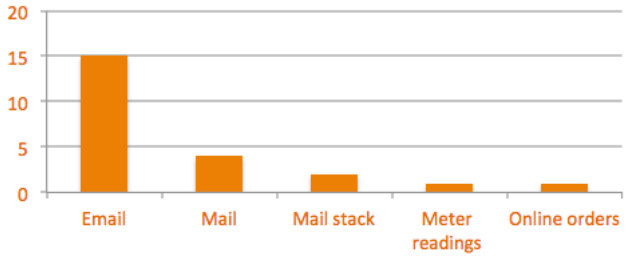

Fig 4. Interactions with communications.

350 interactions were recorded with FMCGs in home A, 291 in home B. These spanned an enormous range of things, which we have parsed into sub-categories for presentation's sake (Fig.5). The bulk of interactions revolve around foodstuffs in both homes. Interactions with personal grooming, cleaning products and detergents were also pronounced in both homes, as was interaction with packaging and its recycling. Gas, a service in home A, was also prominent in home B, where it has to be bought in in bottles rather than by mains supply.

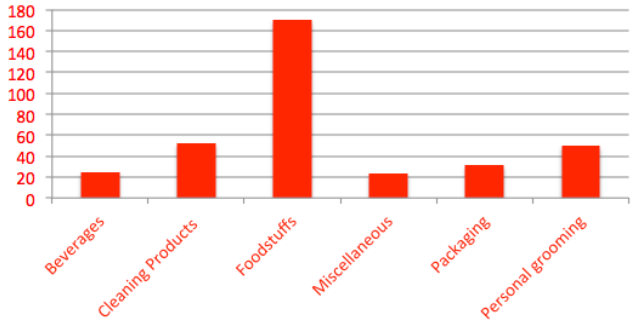

Fig 5. Interactions with fast moving consumer goods.

Furniture was the second most interacted with category of thing in both homes. 354 interactions were recorded in home A, 466 in home B. Interaction largely revolved around cupboards, drawers, shelves, work surfaces, tables and chairs, and reflects the sites where Utensils and Other Equipment are stored and used, and FMCGS are prepared and/or consumed (Fig.6). Another anomaly in home B was a pronounced degree of interaction with internal doors, which are kept closed to keep cats out of rooms.

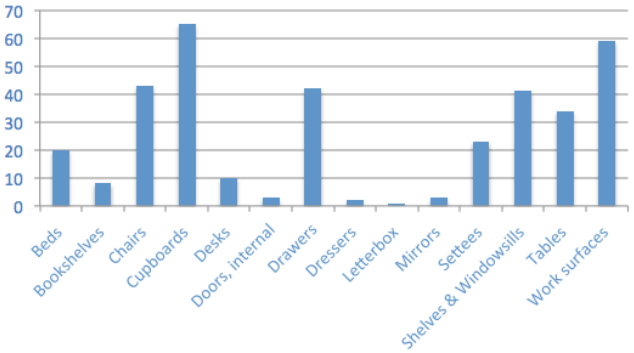

Fig 6. Interactions with furniture.

115 interactions with Media and Media Equipment were recorded in home A (Fig.7), 311 in home B. A broad range of things fell into this category, not just music, text and film, and again we parse these for presentation's sake.

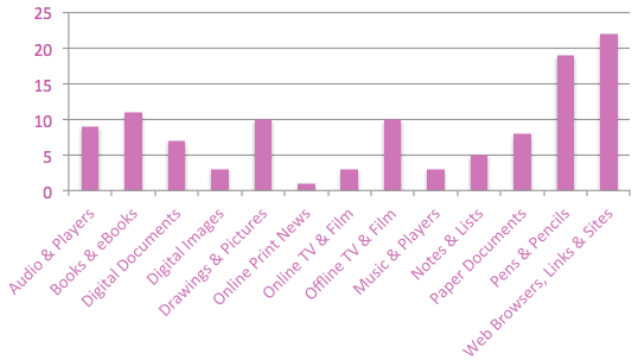

Fig 7. Interactions with media and media equipment.

Fig.7 suggests that interaction with web browsers, links and sites is predominant, but in reality this largely dissolves into interaction with online media and media players (largely radio and on demand TV). The dissolution makes it visible that there is still a good deal of interaction with physical media in the home, with approx. 40% of interactions revolving around paper-based media in home A, 25% in B.

Services, Fixtures and Fittings includes 'built in' things, 'plumbed in' things (Fig.8a) and 'wired in' things (Fig.8b).

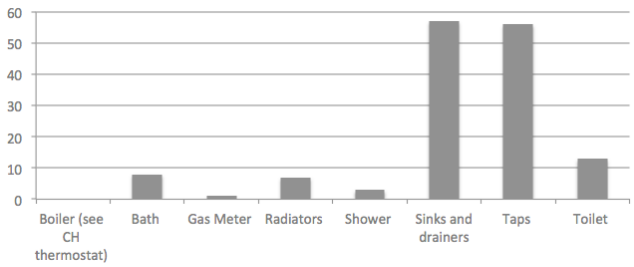

Fig 8a. Interactions with 'plumbed in' services.

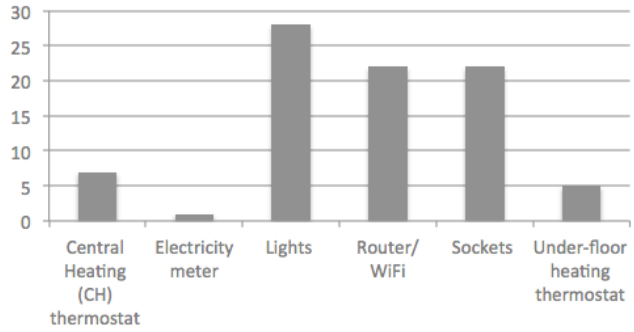

Fig 8b. Interactions with 'wired in' services.

260 interactions were recorded with things in this category in home A, 292 in home B. Interactions with 'built in' things includes external doors and windows, walls, floors, ceilings and stairs. Interactions with 'plumbed in' things revolved predominantly around sinks, taps and toilets in both homes (Fig.8a). Interaction with 'wired in' things (Fig.8b), particularly lights, sockets, routers/WiFi, were also predominant in both homes. Interactions with heating thermostats were also pronounced in home A, which were largely to do with over-riding automatic settings, but not in home B.

43 interactions with Toys were recorded in home A. Toys was replaced by Living Things in home B (plants and cats) and 91 interactions were recorded. Plastic toys and fluffy animals were the largest category of things interacted with in home A, and real animals (cats) in home B.

As noted above, the biggest single category of thing interacted with in either home was Utensils and Other Equipment: 536 in home A, 553 in home B. Like FMCGs and Media, a great many things were interacted with here and they have again been parsed into broader categories for presentation's sake (Fig.9). Crockery was the largest category of thing interacted with in both homes, and the other things implicated in preparing and eating food, cleaning up, and disposing of waste were similarly pronounced in each.

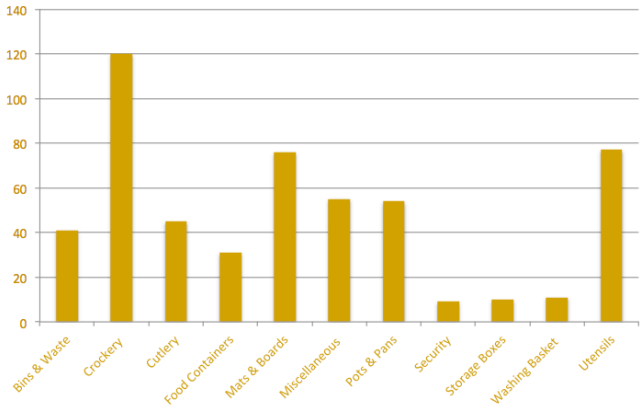

Fig 9. Interactions with utensils and other equipment.

Before we move on to consider what these numerical patterns start to show us of the animal in the foliage, we offer one final graph that caught our attention. Fig.10 depicts the overall number of interactions by category in which *computation* is embedded.

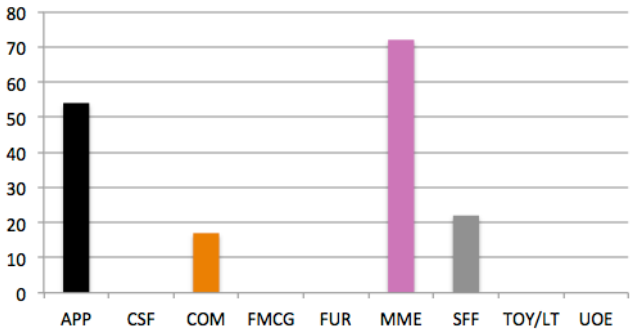

Fig 10. Computational interactions.

Only 8.3% of interactions implicate computers in home A. This figure rises to 20.4% in home B. Despite the difference, the *profile* of computational interactions in the home is the same in each home: it only penetrates 4 categories of thing, and it does so in the same ways, with Media and Media Equipment being predominant, followed by Appliances, Services (both of which are implicated in the consumption of media) and Communications. It would seem that there is much scope to extend the *reach* of computation in the home.

MAKING SENSE OF THE NUMBERS

Fig.11 shows what the numerical patterns 'look like' when transposed onto the physical space of home A. The transposition makes it visible that interaction with things is manifest in very particular locations or *interactional zones* in the home (the same is true for home B). These are similar to Koile et als [18] "activity zones", which "represent location and motion contexts" and are "learned from statistics of human behavior." They also resonate with Crabtree et als [5] "ecological habitats" and "activity centres" – particular locations within the home where things coalesce – but are far more diverse in character, covering not only media and communications but a whole gamut of things interacted with in the home on a daily basis.

Interactional zones are not rooms (e.g., the master bedroom *#A* Fig.11, or child's bedroom *#B*, or spare bedroom *#C*, etc.). They are distinct zones within rooms where interaction with things naturally occurs and where things *cluster* together. Thus we can see, for example, that there are 2 distinct zones of interaction in the master bedroom (zone *#A*, Fig.11) – the bed, and the drawers. Similarly we can see the particular categories of things that cluster together in these locations: media, communications, appliances, services, clothes and soft furnishings, furniture, utensils and other equipment, FMCGs and toys in and around the bed; media, appliances, services, clothes and soft furnishings, furniture, utensils and other equipment in and around the drawers. We can see too the *proportion* of interactions with particular categories of thing in these zones: that clothes and soft furnishings are interacted with most in and around the bed, for example, and appliances in and around the drawers, and that interaction with media and media equipment is pronounced in both zones.

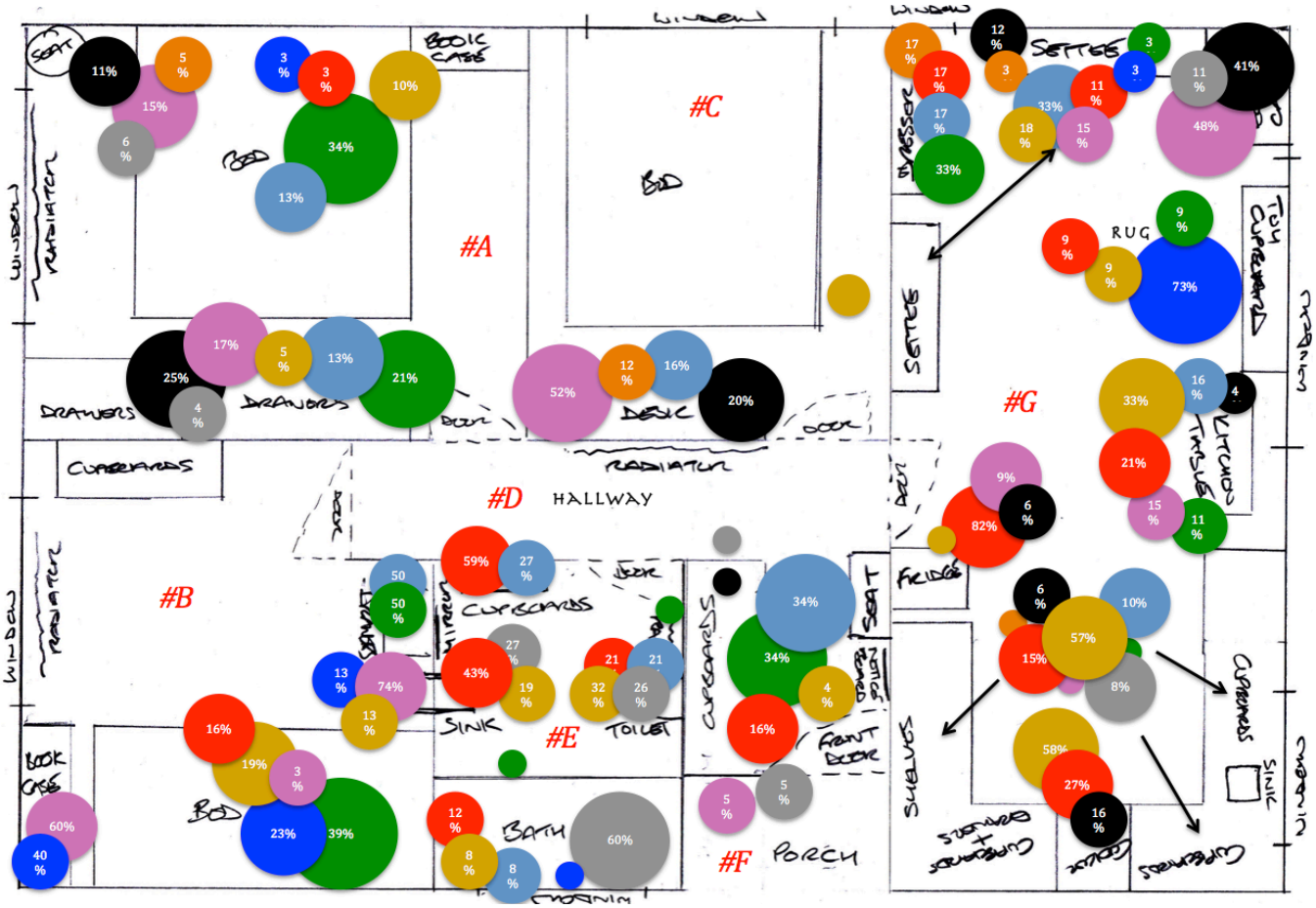

Fig 11. Interactional zones and clusters of things.

Our initial descriptions, which provided for the numerical patterns, also allow us to identify the particular things interacted with in these zones. Thus, and for example, we can see that the clusters of interaction in and around the bed involve radio and online print news (media), email (communications), tablets and phones (appliances), wifi (services), bed linen (clothes and soft furnishings), the bed (furniture), cups and plates (utensils and other equipment), food and drink (FMCGs), and toys. Similarly, we can see that the PC and clock (appliances), film and TV (media), electricity and wifi (services), clean clothes and dirty clothes (clothes and soft furnishings), the drawers themselves (furniture), and washing basket (utensils and other equipment) coalesce in and around the drawers.

What we see when we transpose the numbers onto the physical layout of the home is distinct interactional zones within each room. In the child's bedroom (*#B*, Fig.11) we can see that interaction with things clearly clusters around the bed, the bookcase, the desk, and the drawers; in the spare bedroom (*#C*), the desk; in the hallway (*#D*), the cupboards and seat; in the bathroom (*#E*), the bath, the toilet, the sink, the cupboards; in the porch (*#F*), the mailbox and the door; and in the kitchen (*#G*), the kitchen cupboards, shelves and work surfaces, the cooker, sink, fridge, kitchen table, rug, bookcase, settees and dresser. Furthermore, each of these interactional zones is possessed of its own unique interactional characteristics: it's own *unique clustering* of things.

We would add to this, that these unique clusters are spatially and temporally distributed. Fig.11 invites us to see distinct patterns, particular clustering's of things in particular zones, but the patterns, the clusters, are *assembled across space and time in interaction*. The clusterings are dynamic. Take, for example, the presence of FMCGs in the master bedroom and it soon becomes clear that they had to get there somehow, from some other zone – the kitchen, where tea and toast is made, which implicates particular clusters of things (furniture, appliances, services, utensils, etc.) in its achievement. The upshot is that the clusters are not independent but inherently connected in interaction.

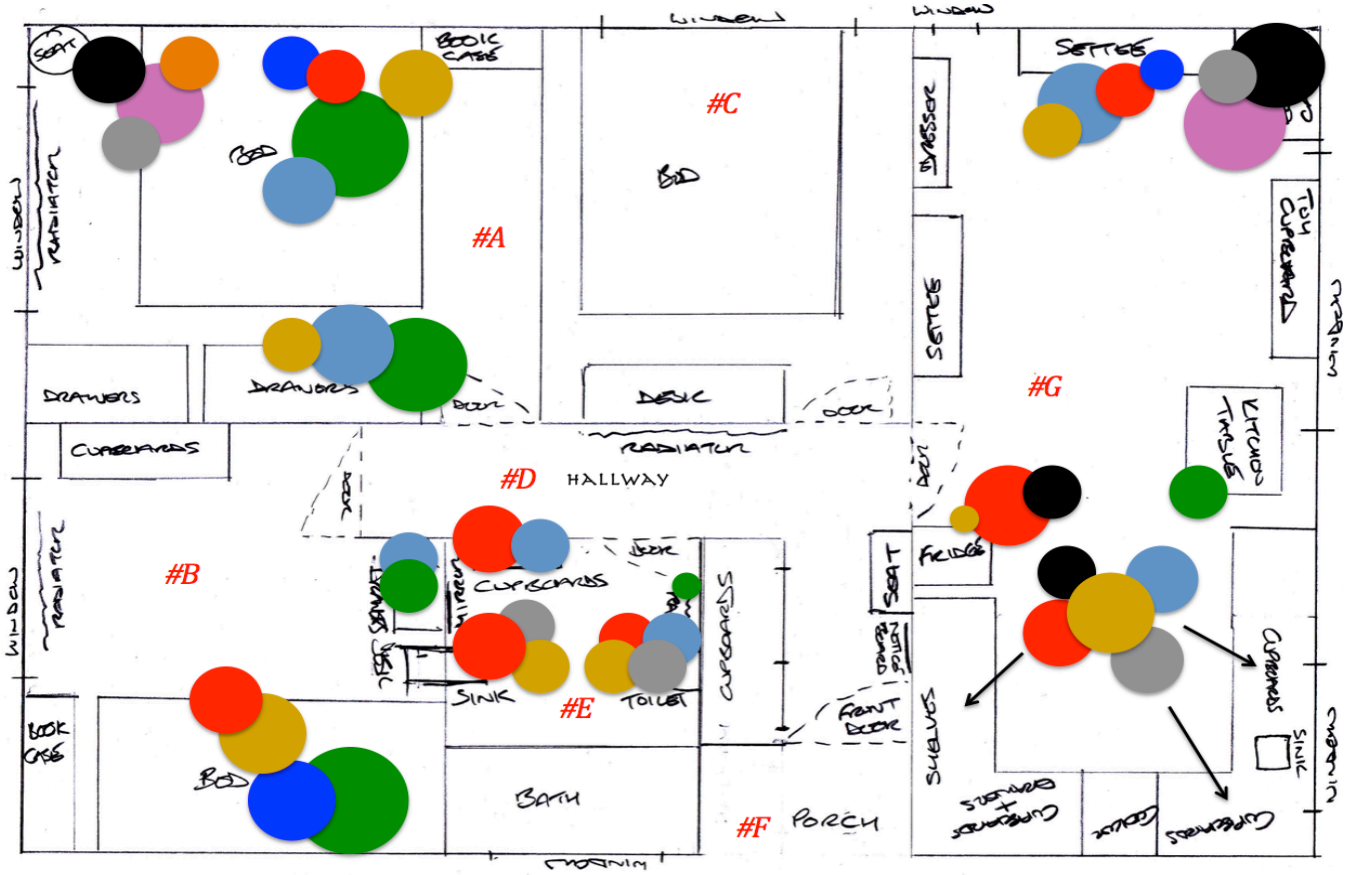

Fig 12. Spatially distributed rhythms and routines.

The Animal in the Foliage

The 'connected' character of interactional zones and clusters orients us to the phenomenon that gives the data its real world, real time *sense*; that is, it's sense *in* interaction. All of the data presented so far gains its sense from the particular *rhythms and routines* that constitute everyday life in the home, and the mundane activities in and through which these are brought about. This is not, of course, the

first time that attention has been drawn to the salience of domestic routines to design [e.g., 5, 6, 34], but as with previous elaboration of ecological habitats and activity centres, the scope extends far beyond domestic routines in which media and communications are embedded.

Fig.12 illustrates, for example, the interactional zones and clusters implicated in the domestic routine 'getting up in the morning' in home A, which includes making breakfast, getting washed and getting dressed. In doing so it surfaces the spatially distributed nature of this routine and the zones in and across which it takes place. The reader will note the absence of definite proportions in Fig.12, as the aim here is simply to render the unique zonal clusters of interactions implicated in the routine.

What can't be seen, but can be recovered from our initial descriptions of human-thing interaction, is *what is being done* in and across these zonal clusters. Thus, and for example, the daily 'get up' in home A begins with the radio being played over wifi on an iPad in the master bedroom; visiting the toilet is the next step; then entering the kitchen, turning lights and lamps on, filling the kettle, putting bread in the toaster, tea in the pot, getting cups and plates off cupboards and shelves, knives out of drawers, butter and jam from the fridge; turning the PC on next to the settee and putting a child's programme on, serving them breakfast on the settee and taking breakfast for a partner through to the bedroom. Thus the routine unfolds in the details of particular interactions with particular things in and across particular zones in the home until everyone is fed, washed and dressed and ready for the next part of the day to unfold.

It is in the details of our mundane interactions with things, done as *part and parcel* of the routine activities that bring the daily rhythms of the home about, that we rub up against the animal hiding in the foliage. What the zonal clusters reveal is that domestic rhythms and routines are brought about not just through human interaction, but through the *methodical assemblage of things* in the course of doing interaction. The daily 'get up', for example, starts methodically through the particular interactional assemblage of things: bed, iPad, seat on which it sits overnight, browser, bookmark, live radio stream; it proceeds through the methodical assemblage of toilet, sink, soap, towel and radiator, off which the towel is hung; it moves on to the methodical assemblage of lights, kettles, cups, plates, cutlery, foodstuffs, works surfaces, etc.

It might seem strange to speak of methodical assemblages with respect to work surfaces, bed, toilets, sinks, lights, etc., insofar as the notion of an assemblage hints at the moving around and putting together of things. Clearly we don't move the bed, the toilet, the work surface, etc., around, or at least not routinely, but we do put such things together with other things *in* interaction. It is worth noting as well that while a great many things are fixed-in-place the fixing or placement is methodical: you don't place and fix a toilet in your kitchen, for example, whereas you do place and fix tables, sinks, cupboards, etc. Where things are placed and fixed in the home is, for the most part, no accident. Rather, they are placed methodically with respect to their relevance to interaction.

Methodical assemblages of things are multi-faceted then. They consist of methodically placed things and they consist of methodical assemblies of things, and methodical uses of things. Methodical assemblies consist of those things brought to and put together at sites where things fixed-in-place reside. The kitchen is a classic example, where cutlery, crockery, pots and pans, foodstuffs and utensils are methodically assembled on work surfaces in the routine making of food, though there is more to assemblies than this. They are also to be found in the places where things live (fridges, drawers, cupboards, shelves, etc.). Methodical assemblies of things run throughout the house and can be found at any site where things are fixed-in-place.

Methodical uses of things are also to be found as a feature of methodical assemblies. The iPad example above illustrates this, and the methodical use of things pervades our domestic routines. We use toothbrushes, toothpaste, soap, towels, knifes, forks, plates, cookers, fridges, etc., etc., etc., in very particular, methodical ways. We don't use plates to read on, for example, or butter knifes to shave with, or cookers to sit on and eat our dinners. Method pervades our use of individual things and the assemblies individual things are part and parcel of. When we look at the methodical use of things it is also clear that their use is 'account-able' [11]. Your partner would, for example, call you to account if you were to try shaving with a butter knife or, more prosaically, if you were to use her cup to have your coffee in (something that would assuredly happen in either home A or home B).

The strong point about the account-ability of things, as given in their methodical use as features of methodical assemblies implicating methodically placed things – that is, as features of methodical assemblages of things in the home that are manifest as zonal clusters – is that they provide for the *recognisability* of interaction. We can see what is going on, what is being done, what has been done and even what needs to be done, through the methodical placement, assembly and use of things in the home. You can walk into your home and a host of events past, present and future are available to you at-a-glance through the methodical assemblages of things that confront you: the children have been playing in the living room, mum is about to have a bath, the washing needs folding and putting away, etc.

Now that we can 'read off' domestic events from methodical assemblages of things, that they are account-able, is the case for all of us, but it is the case in a very unique, very *local* way. 'Your' home is not the same as 'my' home. While you may do much the same as me – get up, get dressed, make breakfast, etc. – how you do them, through just what methodical assemblages of things, will be different. Some of the assemblages I might recognise, other

people might do so too, but others will be opaque. We might recognise the things involved in the interaction, but not what is being done, has been done, needs to be done, etc. Could you tell from seeing a spoon in my sink at a certain time of day that the cat's had been fed, for example?

The account-ability of methodical assemblages resides in and reflects the *local order* of domestic life: how you and the people you live with (should you do so) organise life at home. That organisation is manifest as and articulates your domestic rhythms and routines, which are recognisably constituted in your methodical interactions with things and the unique methodical assemblages that are produced in and through those interactions. This means that zonal clusters are 'indexical' to the local order, that they get their sense from the local order and that their sense resides in the local order, all of which raises some serious challenges for the Internet of Things.

SO WHAT?

We might begin to open up the implications of our study by considering some of the ways in which issues might be raised about the approach that has been adopted here and its focus. In reviewing this paper it was suggested to us, for instance, that the indexicality of zonal clusters to the local order ignores how the 'non-local' is also indexed within them. Such an argument invites us to see broader "world systems" [22] at work within the local production of order – for example, the machineries of capitalist mass production and marketing implicated in local interaction with FMCGs. On this view there would be a need to tease 'degrees of localness' out of our study and the ways in which the 'local' and 'non-local' might be seen to be related.

Dwelling on the implicative relationship of world systems to local interaction with things in the home would, however, gloss over the phenomenon that our study *surfaces:* the methodical assemblage of things involved in the accomplishment of domestic rhythms and routines. Our attention would thus be diverted from the observable and reportable fact that people *build* such assemblages *in* interaction, and do so as a matter of course in carrying out the plethora of activities that make up domestic life. The machinery of mass marketing would, then, be put in place of a distinctive machinery of interaction implicated in the ongoing, day-to-day, accomplishment of the local order. This does not rule out further treatment of the phenomenon, social and technical, but there is in our view a need to proceed with caution if we are not to lose sight of it.

The 'invitation' to make the local accountable to world systems is not all that it appears on the surface – i.e., a matter of teasing out how the machineries of capitalist production relate to the local order. As anthropologist George Marcus (who has valorised the notion of "world systems") reminds us, efforts to tease out the relationship between situated action to large-scale social structures (e.g., by tracking the "connections between sites" [22]) are embedded in a particular social science discourse that is deeply concerned with the "politics of knowledge" [21].

While Marcus' work has been imported wholesale into design by [10] we should not accept this way of understanding the social, which transforms fieldwork and ethnography more generally into a reflexive form of political critique, as *given*. It is not. Indeed, it is bitterly contested within the social sciences [e.g., 20] and in systems design [e.g., 7]. The study reported here is rooted in a long tradition of empirical studies in CSCW inspired by ethnomethodology spanning workplaces, homes, games, etc. Such studies are "incommensurate and asymmetrically alternate" [13] to theoretical treatment of whatever colour, shade or hue.

We *cannot* then make use of theory to add what some might see as 'breadth and depth' to our study, other than as a topic of ethnomethodological critique [19]. There are limits to how far this can be taken here so the reader is referred to [4] for further treatment of these issues. Suffice to say that in place of theoretical insight we offer empirical observations and reflections on what they might mean for design. The key takeaway we offer is not that people ordinarily interact with lots of things in the home and that these cluster together in certain sites, but rather that key to the ordering of domestic life, and the routine accomplishment of domestic activities, is the *methodical* ways in which household members assemble things.

This observation has particular ramifications for the development of the Internet of Things, which is largely marked by the design of *individual things* to be placed in the home: the Internet-enabled fridge, washing machine, thermostat, kettle, etc. The development of individual things creates a *fragmented ecology* in which things are not connected together; they are only connected to the Internet. Where assemblages of things are provided for – e.g., If This Then That or Samsung's ARTIK platform – the provision is largely limited to the placement and connection of various sensors. These are not designed to 'fit' into or support existing methodical assemblages, but to enable designers and/or end users to create to novel assemblages exploiting new technological possibilities.

The real world, real time uses of things within the local production of domestic life is, then, ignored by design. Things are not being designed to fit into and support the methodical assemblages implicated in the doing of a great many domestic activities. This may not be seen as problem; new activities will emerge and it is these that design is interested in. However, domestic life will not simply change, and whole swathes of it be dispensed with by design because designers do not build the IoT to support activities that are key to its ongoing accomplishment. That it doesn't support a great many domestic activities may, on the other hand, have a considerable impact on the IoT and limit its uptake, just as a failure to design for the orderliness

of human activities has had on other technologies in other settings (e.g., [3]).

Our study raises the issue of designing for domestic activities by designing methodical assemblages of things – *multiple things, occupying multiple categories*. This means that it is not sufficient to design for FMCGs, for example, but the other things that are methodically implicated in their use need to be taken into account as well, such as utensils and furniture. Designing for methodically produced assemblages of things is a key design challenge, shifting the focus from individual things, and novel assemblages of sensors, to embedding computation in a myriad mundane things situated within the home. In this respect our study opens up the IoT design space.

Our study makes it perspicuous that there is a great deal of scope for embedding computation in the home, insofar as it is absent from most categories of things we have encountered in our study and the things 'contained' within them. Manifold categories of things are routinely *woven together* in practice. FMCGs are used in conjunction with furniture, utensils, appliances and services, and may implicate media (e.g., recipes) and communications as well (who hasn't checked their email or answered the phone while cooking?).

The strong point here is that it may be possible to identify *common assemblages of things* where particular categories of things routinely combine and thereby open up fruitful areas for development to give real world, real time purpose to specific IoT applications. For example, that particular FMCGs (e.g., toothpaste) are used in combination with particular Utensils and Other Equipment (a toothbrush) and Furniture (a mirror) in a particular interactional zone (the bathroom sink) and that these things could be sensed and Internet-enabled to deliver oral hygiene advice.[3]

A third and final takeaway from our study suggests that the methodical assemblage of things might open up a way for designers to get a handle on an old but salient problem to IoT applications that rely on sensing human activities. The annals of ubiquitous and pervasive computing are replete with papers detailing efforts to sense activities in the home, though there is, despite developments, a strong sense in which Tapia et als [32] comments on the effort still ring true:

> "Unlike other machine learning and pattern recognition problems, there is no 'right' answer when recognising activities. The boundaries when activities begin and end are fuzzy since they can occur sequentially, in parallel, alternating, and even overlapping. Finally, there is significant variation in the way observers would label the same activities."

Our studies suggest that there may be a way to get a hold of this "fuzzy" problem: that just as methodical assemblages of things provide human beings with the means to *recognise what has or is being done*, and even *what needs to be done next*, then so they might provide the means for computational machines to recognise it too.

In this respect our study suggests that there are several salient aspects of domestic activity that might be sensed. Not only the particular things used in interaction, but also the unique clusters of things that emerge in the act of assembly, the discrete zones in which these clusters occur, and their spatial and temporal distribution might all be sensed as well to determine what is being done, and where IoT automation and actuation are concerned, what needs to be done next.

This, however, is where the *uniqueness* of the local domestic order bites. As noted above, even where what goes on in one home may be much the same as another, just how it is done, through just what assemblage of things, where it has reached and what needs to be done next may not be transparent to outsiders. Concomitantly, the local order may well be opaque to machines and algorithms. As [36] demonstrates, IoT devices may struggle to learn and respond appropriately to the local context, situations and intent of users, and this is in the case of a single device. Clearly sensing human activity at a local level will be considerably more challenging where multiple devices are involved as projected by the IoT.

Sensing domestic activity at a local level, in distinction to trading in gross patterns across homes (as for example in demand-side energy management), raises real challenges for machine learning. The methodical assemblage of things, along with the detectable spatial and temporal 'states' implicated in their construction, may provide a fruitful means of addressing the problem. We do not pretend that this will be easy. Detecting that A, B, and C things are being interacted with in zone X, that D, E and F things are being interacted with in zone Y, and that G, H, I, J, K, L and M things are being interacted with in zone Z doesn't tell a machine what is being done (e.g., getting up). It only says what has been interacted with where and when.[4]

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[3] In saying this it might be argued that we have swallowed the IoT agenda wholesale, that we lack critical insight, and would do well to learn when it is appropriate to intervene and when not [2]. We are not blind to the issue. As ethnomethodologists have argued since the inception of CSCW, in undertaking design there is need to determine what to automate and what to leave to human skill and judgement [17]. Nevertheless, the proposition here still holds: identifying common assemblages of things may serve to inform IoT design, just as 'patterns' have been invoked on previous occasions to support different design initiatives that seek to capitalise on field studies done in the workplace [23].

[4] Other studies we have conducted focusing on the deployment of sensors in the home suggest that it will be necessary to involve household members in the articulation

Coupled to this, it is important to note the *shift* from sensing interactions with things to the machine-based production of and reasoning about *personal data*. The sense that interaction with things has within the local order is not of the order 'this was opened, that was picked up, this was put in it', but of the order that some particular activity is being done (e.g., going to the toilet). What is being sensed and reasoned about is, then, the activities implicated in bringing the everyday rhythms and routines of domestic life about. These are certainly personal and may, as the example above demonstrates, be very sensitive. How such data is treated is also an important matter to consider within the emerging IoT ecology and raises real challenges of 'human-data interaction' [24, 9].

CONCLUSION

We are not the first to look at things in the home as a resource for design. As Rodden and Benford [26] point out domestic design has largely focused on the "stuff" of the home, i.e., "all the things that twitch around daily to monthly." Our study of a day in the life of things in the home complements and extends such prior work, particularly work done in the ethnomethodological tradition, which has been concerned to explicate and make visible the "unremarkable" character of the domestic order and how it is brought about locally in the accomplishment of the "routine" [34].

Our study does this by offering empirical insights that extend upon matters such as the notion of clutter [31] and mail handling [15] and other "artful systems" in the home [33]. While these studies implicate the methodical assemblage of things, the assemblage has not been treated as a topic in its own right. Rather, the emphasis has been on how people design, arrange and integrate *informational* artefacts:

> " … the miscellany of to-dos, bills, invitations, appointments, school correspondence, schoolwork, etc. that must be routinely handled, arranged and dealt with in the smooth running of a family home." [33]

Although such studies share in common with ours an interest in the organisation of domestic life, without criticism they do not address the methodical assemblage of things as a *pervasive* feature of the situated accomplishment of the routine activities that constitute the local order. That people build such assemblages, and do so as a matter of course in carrying out routine activities, elaborates a distinctive machinery of interaction that is implicated in the ongoing, day-to-day, accomplishment of the local order, whether it implicates informational artefacts or *not*.

There is, then, a great deal more to the methodical assemblage of things than creating "organising systems" [33] of informational artefacts to handle the routine, with the more of the matter having direct implications for the ongoing development of the Internet of Things. Thus, in addition to the kinds of design issues that have dropped out of previous studies, our current study offers the following takeaways:

- Our study makes it perspicuous that the "glue" [34] of domestic life – the routine – in all cases implicates, relies on and exploits the methodical assemblage of things.
- Things are not purposed within the routine individually; this raises the challenge of designing for assemblages of things that span multiple categories, rather than single things or things within a category.
- Future possibilities for IoT development in the home might be identified through the empirical elaboration of common methodical assemblages of things.
- Insofar as the methodical assemblage of things permits household members to recognise what has been done, is being done and/or what needs to be done next, such assemblages might be purposed to drive the activity sensing and machine learning that is needed to drive IoT automation and actuation.

There is, of course, a great deal more that could be said about our study and how it relates to other design and social science literatures. This is not the place, however. The purpose of this paper has been to *surface* a phenomenon of broad relevance to the development of the IoT. A phenomenon that is in plain view, ordinarily seen but unnoticed or taken for granted, that is at work in your home, just as it is in ours, and which is a pervasive feature of the local ordering of domestic life wherever it occurs.

As Sacks [30] put it with respect to the machinery of interaction ordering talk,

> " … the results I offer, people can go and see for themselves. And they needn't be afraid to. And they needn't figure the results are wrong because they can see them."

The same applies to the methodical assemblage of things in the home. This is not to say that your home will look my home or anyone else's - just like conversation, the machinery can be used in infinite ways - though it may transpire that commonalities exist at least within a culture (we would be surprised if they didn't). Nonetheless, there is a need for further work. We have, to reiterate, *surfaced* the phenomenon here. The job now is to open it up through broader study and technological investigation.

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of sensed data to make it legible [35]. Articulation work provides a potential resource for the problem of machine learning in this context.

REFERENCES

1. *4th Annual Internet of Things Awards 2013/14*, http://postscapes.com/internet-of-things-award/2014/
2. Eric Baumer and Six Silberman (2011) "When the implication is not to design (technology)", *Proc. of CHI*, pp. 2271-2274, Vancouver, ACM.
3. Jon Bowers, Graham Button and Wes Sharrock (1995) "Workflow from within and without", *Proc. of ECSCW* pp. 51-66, Stockholm, Kluwer.
4. Graham Button, Andy Crabtree, Mark Rouncefield and Peter Tolmie (2015) *Deconstructing Ethnography*, Springer.
5. Andy Crabtree, Tom Rodden, Terry Hemmings and Steve Benford (2003) "Finding a place for ubicomp in the home", *Proc. of UbiComp*, pp. 208-226, Seattle, Springer.
6. Andy Crabtree and Tom Rodden (2004) "Domestic routines and design for the home", *Journal of CSCW*, vol. 13 (2), pp. 191-220.
7. Andy Crabtree, Tom Rodden, Peter Tolmie and Graham Button (2009) "Ethnography considered harmful", *Proc. of CHI*, pp. 879-888, Boston (MA), ACM.
8. Andy Crabtree, Peter Tolmie and Mark Rouncefield (2013) "'How many bloody examples do you want?' – Fieldwork and generalisation, *Proc. of ECSCW*, pp. 1-20, Paphos, Springer.
9. Andy Crabtree and Richard Mortier (2015) "Human data interaction: historical lessons from social studies and CSCW", *Proc. of ECSCW*, pp. 1-20, Oslo, Springer.
10. Paul Dourish and Genevieve Bell (2011) *Divining a Digital Future*, MIT Press.
11. Harold Garfinkel (1967) *Studies in Ethnomethodology*, Prentice-Hall.
12. Harold Garfinkel, Michael Lynch and Eric Livingston (1981) "The work of a discovering science construed with materials from the optically discovered pulsar", *Philosophy of the Social Sciences*, vol. 11, pp. 131-158.
13. Harold Garfinkel and Lawrence Wieder (1992) "Two incommensurable, asymmetrically alternate technologies of social analysis", *Text in Context: Contributions to Ethnomethodology* (eds. Graham Watson and Robert Seiler), pp.175-206, Sage.
14. Neil Gershenfeld, Raffi Krikorian and Danny Cohen (2004) "The Internet of Things", *Scientific American*, vol. 291 (4), pp. 76-81.
15. Richard Harper, Venetia Evergeti, Lynne Hamill and Ben Shatwell (2003) "The social organisation of communication in the home of the twenty-first century", *Cognition, Technology and Work*, vol. 5 (1), pp. 15-22.
16. Richard Harper (2012) "From the smart home to the connected home", *The Connected Home: The Future of Domestic Life* (ed. Richard Harper), pp. 3-18, London, Springer.
17. John Hughes, Dave Randall and Dan Shapiro (1993) "From ethnographic record to system design: some experiences from the field", *Journal of CSCW*, vol. (1), pp. 123-141.
18. Kimberle Koile, Konrad Tollmar, David Demirdjian, Howard Schrobe and Trevor Darrell (2003) "Activity zones for context-aware computing", *Proc. of UbiComp*, pp. 90-106, Seattle, Springer.
19. Michael Lynch (1999) "Silence in context: ethnomethodology and social theory", *Human Studies*, vol. 22, pp. 211-233.
20. Michael Lynch (2000) "Against reflexivity as an academic virtue and source of privileged knowledge", *Theory, Culture & Society*, vol. 17 (3), pp. 26-54.
21. George Marcus and Michael Fischer (1986) *Anthropology as Cultural Critique*, Chicago University Press.
22. George Marcus (1995) "Ethnography in/of the world system: the emergence of multi-sited ethnography", *Annual Review of Anthropology*, vol. 24, pp. 95-117.
23. David Martin, Tom Rodden, Mark Rouncefield, Ian Sommerville and Stephen Viller (2001) "Finding patterns in the fieldwork", *Proc. of ECSCW*, pp. 39-58, Bonn, Kluwer.
24. Richard Mortier, Hamed Haddadi, Tristan Henderson, Derek McAuley and Jon Crowcroft (2014) "Human-data interaction: the human face of the data-driven society", *Social Science Research Network*, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2508051
25. Daniela Petrelli, Steve Whittaker and Jens Brockmeier (2008) "AutoTopography: what can physical mementoes tell us about digital memories?", *Proc. of CHI*, pp. 53-62, Florence, ACM.
26. Tom Rodden and Steve Benford (2003) "The evolution of buildings and implications for the design of ubiquitous domestic environments", *Proc. of CHI*, pp. 9-16, Ft. Lauderdale, ACM.
27. Harvey Sacks (1963) "Sociological description", *Berkeley Journal of Sociology*, vol. 8, pp. 1-16.
28. Harvey Sacks, Emmanuel Schegloff and Gail Jefferson (1974) "A simplest systematics for the organization of turn-taking in conversation", *Language*, vol. 50, pp. 696-735.
29. Harvey Sacks (1984) "Notes on methodology", *Structures of Social Action: Studies in Conversation Analysis* (eds. Maxwell, J.M. and Heritage, J.), pp. 21-27, CUP.
30. Harvey Sacks (1992) "On sampling and subjectivity" *Lectures on Conversation*, vol. I, pp. 483–488, Blackwell.

31. Laurel Swan, Alex Taylor and Richard Harper (2008) "Making place for clutter and other ideas of home", *ACM ToCHI*, vol. 15, Article No. 9.

32. Emmanuel Tapia, Stephen Intille and Kent Larson (2004) "Activity recognition in the home using simple and ubiquitous sensors", *Proc. of Pervasive Computing*, pp. 158-175, Linz, Springer.

33. Alex Taylor and Laurel Swan (2005) "Artful systems in the home", *Proc. of CHI*, pp. 641-650, Portland, ACM.

34. Peter Tolmie, James Pycock, Tim Diggins, Allan Maclean and Alain Karsenty (2002) "Unremarkable computing", *Proc. of CHI*, pp. 399-406, Minneapolis, ACM.

35. Peter Tolmie, Andy Crabtree, Tom Rodden, James Colley and Ewa Luger (2016) " 'This has to be the cats' – personal data legibility in networked sensing systems", *Proc. of CSCW*, February 27-March 2, San Francisco, ACM.

36. Yang, R. and Newman, M. (2013) "Learning from a learning thermostat", *Proc. of UbiComp*, pp. 93-102, Zurich, ACM.