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ORIGINAL ARTICLE

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Homes that make us smart

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Abstract In this article we consider what it should mean to build ''smartness'' or ''intelligence'' into the home. We introduce an argument suggesting that it is people who imbue their homes with intelligence by continually weaving together things in their physical worlds with their everyday routines and distinct social arrangements. To develop this argument we draw on four ongoing projects concerned with designing interactive surfaces. These projects illustrate how, through the use of surfaces like fridge doors and wall displays, and even bowl shaped surfaces, we keep in touch with one another, keep the sense of our homes intact, and craft our homes as something unique and special. Intelligence, here, is seen to be something that emerges from our interactions with these surfaces—seen in the thoughtful placement of things throughout the home's ecology of surfaces. IT for the home is thus understood less as something to be designed as intelligent and more as a resource for intelligence.

Keywords Surfaces · Home · Smart homes · Domestic technology · Ethnography · Prototyping

With apologies to Don Norman.

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1 Introduction

Computing research within the domestic realm has been, until recently, heavily weighted towards the idea of a *smart home*, with several ongoing and prolific research programmes in place, including Georgia Tech's ''Aware Home'', MIT's ''Place Lab'', Samsung's ''Smart Home Project'' and Microsoft's ''MS Home'' to name but a few. To put it crudely, the goal here has been to explore the ways of using computing to make homes more *intelligent*. There is much to recommend the combination of ubiquitous and pervasive computing that has resulted from such projects, although to date the most obvious benefits (still more hypothetical than real) have been for the handicapped, the aged, the sick and so on. With a smart home, disbursement of medicine can be monitored and managed; accidents that might befall the elderly can be observed and medical intervention summoned if necessary. In this sense, what was before merely a set of walls and enclosed spaces becomes an infrastructure with technological intelligence, able to monitor, look and act at appropriate points. Leaving aside, for the moment, what one might think of this particular view of ''intelligence'', achieving these benefits requires a specific type of *networked-smart home* experience, replete with sensors, monitors and cameras of various kinds. Unfortunately, for home dwellers without the particular needs of the aged or sick, both the complexity of these technologies combined with their unfamiliarity demands a very high level of perceived benefit before they become appealing. Indeed, if the history of research into this area attests to anything, it is the narrowness of the appeal of *smart homes* to a wider population [1–3].

Here in the Socio-Digital Systems group at MSR Cambridge, we are investigating a different view on what smart homes might be. Our efforts have been not to design technologies for specific and unusual needs through the implementation of networked technical infrastructures. Rather, we start from an altogether

different assumption: we think of the home as already smart, smart not in terms of technology, but in terms of how people conduct their lives in the home. Recognizing this, our approach is to augment and support these existing practices, learning from the ways in which people already live their lives, and the tools and artifacts they draw on to do so. This way of thinking results in technological concepts that are quite different from those typically found in smart homes. In this paper we want to present some of the research that reflects this perspective, offering a short history of, and prospects for, our own efforts to augment human endeavour. Our goal is less about affecting the built infrastructures of a house and more about enhancing the resources for the particularly human art of making a building into a home [4].

In presenting our work, we explore a particular theme that highlights how we see human intelligence at play. In particular, we focus on what might seem to be the most obviously unintelligent and mundane aspect of homes: namely, surfaces such as fridge doors, notice boards, kitchen walls and even sides of bowls. We explore how these surfaces are transformed from being merely the materials that constitute a house into resources for the organisation and enrichment of home life. Having examined this, we then elaborate on some of the ways in which we have extended the power of these surfaces as instruments, through the use of computing.

2 Background

We are, of course, not the first to focus on surfaces in the home nor on the potential of digitally augmenting them. Attention has been given to picture frames, for example [5], digital pin-boards [12], and much else beside [6–8]. Our concern, though, is not to simply treat surfaces as places in which digital capabilities may appear, but to treat them as part of an ecology within a household. Thus we wish to approach surfaces from the perspective of what surfaces do for the people who occupy a home. This harkens back to Norman [13] in the *Psychology of Everyday Things*, who noted how the placement of information in particular places can act as memory aids.

More recently, our interest is reflected in numerous other research endeavours, specifically the work of Crabtree and others from the UK-based *Equator Project* (http://www.equator.ac.uk/). Their work situates surfaces (including digital displays) in the wider context of everyday routines in the home, and considers what part they play in broader ecologies. Indeed, their work foreshadows some of our own ideas by introducing the idea of multiple sites of display and the interrelations between them:

"we consider displays as heterogeneous collections of fragmentary sites constructed where trajectories collide and where displaying goes on to provide for communication and the coordination of practical action [9, pp. 172]."

In the empirical example they use to develop their points, Crabtree *et al*. detail how paper mail is displayed in home settings. In doing so, they operationalise previous work from Harper and Shatwell [15], outlining an analytic sensibility for considering situated displays by introducing two instructive terms, *coordinate displays* and *ecologically distributed networks*. The first of these terms captures how displays, such as the placement of paper mail on kitchen tables, are incorporated into, and partly constitute, collaborative arrangements between household members. The second term addresses the ways in which displays are placed throughout settings like the home and, by doing so, how they come to constitute networks of interconnected displays. Their analytical orientation and the terms Crabtree et al. [9] introduce succeed in orienting design around the general idea of display surfaces having particular properties that shape or constitute everyday practice. They also give strong weight to determining where displays should be situated in the home.

Despite their detailed analysis and useful orienting principles, however, Crabtree and his colleagues have stopped short of articulating how their thoughts might be developed in practice with respect to design and design guidelines. It is not clear, for example, what material properties should be considered when designing a display solution for a household's "coordinated arrangements"; nor do they answer what properties of a display lend themselves to sustaining or augmenting the ecologically distributed networks that households establish. Perhaps most strikingly, they do not answer the question of *what* information should be put on any display. They recognise that surfaces are used in an ecology, but do not say what the constituent information displayed in the ecology might be.

We have been trying to answer these questions ourselves. By investigating how (and why) some surfaces lend themselves to some forms of display and interaction whilst others do not, and by looking at how some display surfaces work well in combination whilst others may detrimentally compete with one another, we have begun the task of mapping out the informational content displayed on various items within an amalgam of domestic surfaces. In short, we have begun to define, build, and in some cases test, various "interactive surfaces" for the home. These surfaces and the content they display are not, in our view, intelligent in themselves, but enable householders to more intelligently undertake their lives.

This ongoing research has involved several fieldwork studies in family households in the UK, specifically in the London and Cambridge areas. Over sixteen homes, drawn from a mixture of socioeconomic and demographic segments, have participated in the various studies. In practice, the fieldwork has ranged from exploratory or investigative studies, examining existing, ordinary routines in family life, to studies where we have deployed working prototypes. The latter prototyping has been used both as a means to test concepts as well as

a strategy to further explore the distinctive features of family homes.

3 Fridge surfaces and augmented refrigerator magnets

The first example we would like to turn to emerges from our investigations into fridge surface use in family homes. As most readers will know from their own experience, one of the notable properties of fridges is their relatively large display surfaces (although this can and does vary between houses and indeed between countries). Indeed, if fridges are oriented in certain ways, households can find they have two and sometimes three large surfaces available: the front and whichever sides are accessible. This expanse of space can be put to good effect in some simple but nevertheless useful, and in our view intelligent, ways.

A fridge's different physical regions can be assigned to particular uses and even allocated to particular people. For example, the lower regions of family fridges are often taken over by items belonging to children, while higher up, one may find "working" areas containing shopping and to-do lists and other organising items for "Mum". Scattered across these zones, more often than not, are memorabilia (Fig. 1).

In some cases, the divisions between the different regions can be more formal. One side of the fridge might be given to a household's organisational items, the front to family photos, and the lower areas to children's things (Fig. 2). Such organisation has the advantage of making it clear whether items are associated with specific activities or belong to particular household members. Spatial patterning can also be used to signify the change in status of items: a party invitation moved from a fridge's working area to its family display area can signify that the action has been taken to accept the invitation, for instance. Regardless of the particular arrangements, the salient point is that fridge surfaces lend themselves to having an array of heterogeneous items attached. The fridge's form—the height of its surfaces and it's separated sides—helps in offering a simple way to categorise materials. All of these arrangements, enabled by the fridge's form, are controlled by those in house.

Fig. 1 Haphazard display of photos, artwork and invitations

Fig. 2 Working area to left plus "family history" displayed on fridge door

Of course, it could be that any surface in the home would afford the same utility; but part of our approach is an understanding of what it is about the particular site of a surface that gives specific properties. As we have mentioned, our own research and others have noted that *where* a display surface is situated in the home is key to understanding *what* is displayed, as well as when, how and to what ends. The same holds true for fridges. In nearly all homes, fridges are in the kitchen and thus seeing fridge surfaces is an almost unavoidable consequence of ordinary life—when preparing meals, making drinks, snacking and so on. Indeed, in most homes the established moral order, if you will, gives household members the right to be in the kitchen, use the fridge and to consequently view the contents attached to the fridge, whether they want to or not. The fridge provides a surface, which is not only "public", but also inexorably interleaved with the rhythms of the home.

What we see then is that fridge doors and sides become interactive surfaces of a particular sort, holding some materials, but not others; affording a particular range of interactions that weave into ordinary routines. In short, the physical form of fridges and the way in which use of that form is embedded into a home's social organisation set it apart from other surfaces. Surfaces on fridges become, in our terms, intelligent surfaces not in what they do, but in the ways they are used. Our claim is not merely that, in the home, various surfaces are "interaction and display points"—this much is obvious. This discussion of fridge doors and sides is intended to show that what makes homes *intelligent* is how surfaces (amongst other things) are used to display material in particular ways. The intelligence, in our way of looking at things, is in deciding where things are put, how those

things are put, when and with what intended effect. Fridges may be dumb, but the way artifacts are attached to them is not.

With this in mind, we consider ways that we might assist this intelligence with digital means. Rather than substituting fridge doors with digital alternatives, we are interested in exploring ways of letting fridge doors (and sides) do more for the user. We have begun by focusing on a distinctive property of fridges that enabled the intersection of where, how, what and when: namely, that most fridge doors are magnetic. Magnets allow all manner of items to be attached to fridges; things can be attached anywhere with little or no thought and their movement and removal is trivial. This enables a fluidity to fridges as a display—things can be easily moved into, around and between the different regions and no prescribed arrangement is enforced. The design concepts we have derived from these seek to augment this magnetic property to further enhance the fridge surface's useful functions.

In the first instance, we have conceived of *reminding magnets*. Somewhat perversely, things left as reminders on fridge doors are often forgotten about. Our reminding magnets are a lightweight solution for drawing attention to items in unobtrusive ways. In one version of the concept, moving the magnet causes it to glow for some period of time thereafter, drawing people's attention to items that are newly attached or newly rearranged (Fig. 3a). In another version (Fig. 3b), magnets that glow on specified days can be attached to items which need to draw attention to themselves on those days such as appointments and party invitations.

A second concept builds upon the practice of putting important and frequently used items like shopping lists and school term dates in specific places on fridge doors. The *fridge-glance* concept is designed to overcome the problem of accessing this material when away from home; for example, when shopping or making calendar arrangements. Incorporating an in-built camera, the concept allows items placed within a purpose-built magnetic frame to be remotely viewed via a camera-phone or Internet browser. The frame is meant as a visual cue, a mnemonic, demarking an area where items can be casually placed to be remotely accessed. In this way, the design takes into account the informal, offhand use of fridge surfaces, but remains sensitive to the importance of particular attached materials.

A third concept, *talking magnets*, is intended to help "annotate" the materials placed on fridges. Annotations could be useful when additional information about an item is needed. By dynamically labelling a magnet, that information can be quickly conveyed and easily changed. Differences in design could reflect differences in purpose: one might make it clear who a message is from (Fig. 4a) whereas another could provide the message itself where identity might not matter (Fig. 4b).

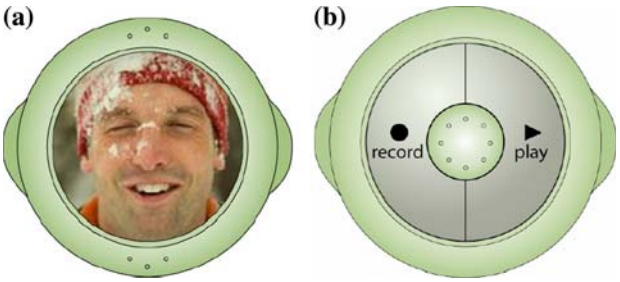

Fig. 4 Magnets that allow items on fridge surfaces to be annotated: **a** indicates who created it and **b** allows voice recordings

At the moment, these are initial concepts, ones we used to explore how we might augment what people do with particular surfaces. Our ideas consist of using digital means to give greater conspicuousness to reminders, making remote access possible and allowing "digital" annotation. We are not, at this stage, certain that these are all or even the best ways one might achieve the enhancements we have in mind. But in initial paper prototyping exercises, the overall response to these concepts has been largely positive, with five different households interviewed having their own particular favourites. Of relevance to the general theme of surface ecologies has been the reaction to the straightforwardness of the designs. Households were struck by the inherent simplicity of what they initially thought to be yet more "technology" for the home. They responded positively to the idea that they might be able to operate the magnets almost without thought. This provoked a sense that the magnets would compliment the ways a fridge, as a surface, is used. As the mother in one household put it: "The most important thing is that they are easy to do, that you do not have to turn them on. You can use them on your way to the sink to do the dishes or something."

4 Situated messaging in the home: homenote

Our second example relates to another kind of messaging, though this time going beyond the boundaries of the paraphernalia found on fridges. We are thinking here of how certain "low tech" artefacts, such as paper notes and Post-It notes, whiteboards, corkboards, and paper

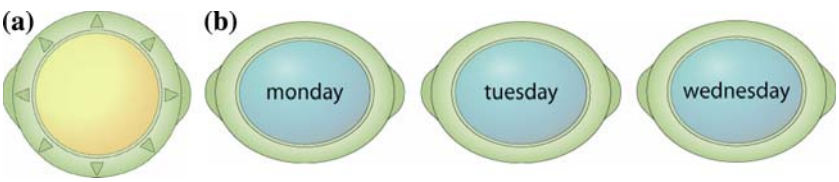

Fig. 3 Magnets that glow when moved from one place on the fridge to another, drawing attention to attached item(s): **a** glows for 24 h once moved, **b** glow on the labelled days

calendars are used for within-home communication, for messages between members of a house when they are at home. These particular forms of messaging, some of which appear on fridge doors but elsewhere as well, are strikingly non-computational. These mundane artifacts also have some distinct properties. As we have already described with refrigerator surfaces, the placement of these artifacts within the home, both physically and socially, is critical to their use. A note placed on the refrigerator door (and even where on the door it appears) has implications for who will see it and how it will be used. Further, people make particular decisions about where best to leave a note for someone else; there often being places in the home or "communication centres" where important messages are left (see Crabtree et al. [9]). Additionally, it is in the nature of these artefacts that, because they are inscriptions on paper, or on other display surfaces such as a whiteboard, they have a visual, static persistence or "epigraphic" quality to them. There are two implications of this. First, they attract attention to themselves in the periphery and as a consequence of everyday activity. For example, notes are placed in such a way that the right people will "come across" them when they are needed and in the course of their routine activities. Thus, they are "pushed" to people's attention in often-subtle ways. Second, because they are visually displayed in this way, depending on where such notes are placed, they can be accessible to anyone present in a particular room or area of the house. Thus they are, in a sense, publicly "broadcasting" to no one in particular, but to anyone present.

Contrasting this with remote communication technologies, we can see at once that many of these are "placeless" rather than situated technologies. The mobile phone and email, in particular, are "person-to-person" rather than "person-to-place" technologies. In other words, if I send an email, I have no real assurance *where* my message will be received, only who will see it: it may be that it will be read at work, at home, or even on the road. If I call someone on their mobile phone, I have no real certainty about where and under what circumstances that call will be received. Remote communication technologies also differ in that they rarely push themselves to attention as a backdrop to other activities. They are more often foregrounded activities demanding attention, such as the ring of the telephone, or they may require the user to make a deliberate decision to check for email or voice messages. Thus, they are often "pull" rather than "push" methods of communication. A final difference is that because remote messaging is often dynamic, transient, and hidden from view (such as voice messages or email), they do not naturally lend themselves to broadcasting to more than one person, or indeed to a household.

Our development of a prototype technology called HomeNote was motivated by the proposition that the unique affordances provided by paper-based messaging in the home, combined with the ability to remotely create them, would generate some compelling new design possibilities. More specifically, in building HomeNote, we wanted to explore the unique affordances and potential value of person-to-place as against person-to-person messaging technologies in the home. But we also wanted to deploy HomeNote into real households as a kind of "Trojan horse" to allow us to deepen our understanding of home communication. This in turn we hoped would allow us to explore possibilities for new and different concepts based on our understanding of the communication needs of households.

This led us to develop a technology called *HomeNote*. As a starting point, we based HomeNote on *TxtBoard*, a situated messaging device that used the SMS protocol to let members of households broadcast messages home [10]. This device was expressly designed for simplicity with many of paper-like functions and an early trial of TxtBoard with one household provoked some of the kinds of home communication we have discussed. We thus sought to combine TxtBoard's minimal set of functions with properties that might leverage new benefits. Specifically, given that so many of the messaging tools in the home involve inscribing in one way or another, we wanted to build a prototype that supported stylus markings, or scribble, in addition to SMS.

HomeNote itself was constructed from off-the-shelf technology: it was a tablet computer encased in a wall-mountable frame containing GPRS and SIM cards. This provided each device with a unique phone number to receive and display text messages from mobile phones. Because it was a tablet computer, HomeNote also supported locally scribbled notes, or scribble annotations on top of text messages. Users could also switch between messages using the tabs along the top of the screen, create and delete new messages, and see at a glance who sent a text message from the information down the left side of the panel (Fig. 5). Whereas our studies of fridge magnets were paper-based prototypes, HomeNote was built and tested. In total, we built five prototype devices and deployed them in local households for a period of a month or more.

Fig. 5 The HomeNote interface showing a text message overlaid with a scribbled note

We found that HomeNote did extend the ways messaging practices were undertaken, and not simply by combining remote delivery with local display in ways that prior surface technologies like Post-It notes could not. It also encouraged new forms of messaging. That is to say, Homenote did not just stretch the intelligent use of a particular kind of surface; also it helped create new ones.

For example, in supporting remotely created situated messaging, HomeNote demonstrated value for all households using it, allowing them to communicate in new ways. Thus, teenage children could send messages home to reassure *all* the family of their whereabouts, and husbands and wives could text home to say that they were on the train and due home at a particular time. These kinds of messages were not only functional, they also allowed for ways of having a presence in the family, and expressing affection for other family members.

Aside from messages of awareness and reassurance, we also found many messages were, in effect, ''calls for action'' sent remotely to the household. Here we saw that the ability to remotely create place-based messages in the home was also used to valuable effect. HomeNote allowed calls for action to be finessed in new ways. For instance, in one household, one of the daughters would use HomeNote to request a lift home from her shift at the hospital. Here the fact that this message was posted in the background of ongoing domestic activity, broadcasting but not specifying either parent, meant that such requests were viewed as less demanding than might have been done via the telephone. According to this daughter, and indeed her family, the peripheral awareness afforded by HomeNote messages enabled an expressly polite kind of request to be made.

HomeNote was used frequently to broadcast what we came to call ''social touch'' messages to the family. These were ''I am thinking of you'' notes sent generally to a whole household, or addressed to one person in recognition of the fact that others would see it. These would sometimes take the form of scribbled notes, but other times would be sent remotely as text messages. For example, the father in one household regularly sent messages the night before to HomeNote to say ''good morning'' to his whole family, or from work to say ''welcome home'' when he could not be there in person. Thus, the creation of notes remotely, with many of the paper-like qualities we have described, offered a new set of affordances for households.

In addition to demonstrating the value of remote messaging, we also found that because HomeNote supported local scribblings created in the kitchen, it took on the role of a whiteboard, being the place for jotting down reminders, important telephone numbers, shopping lists, phone messages and so on. More interesting, however, was how HomeNote highlighted new kinds of messaging not previously recognized in the literature on communication [11]. For example, we found frequent use of the device for messages that looked like social touch messages, but in fact were more about *broadcasting the identity* of the creator of the message, rather than directed at anyone else. Many of the ''good morning'' messages scribbled by younger members of households, for instance, were signed with a flourish—as if these declarations and ornate signatures were intended to put that person's ''stamp'' in the kitchen. Scribbles in which children announced they were off to bed or had finished exams were also of this nature, drawing attention to them without any particular purpose. We found that it was not just children seeking a visible space for their expression; the father who regularly sent ''good mornings'' to his children complained when his messages were occluded under others or were scrawled on by children. In short, we came to the conclusion that these kinds of messages were playful, sometimes tender ways, of *seeking* affection, or of drawing attention to their creator. They were, if you like, a form of saying, ''do not forget me''.

In summary, this (relatively simple) prototype and its deployment underlined the ways in which the kind of communication that goes on in families is bound to place: to the sensitive—*intelligent* in our language—selection of particular places to put messages. But in addition, the introduction of the device encouraged sensitivity to new forms of communication, where ''placeness'' was linked to affect. Family members appreciated it when others expressed a thought for them. They appreciated it all the more when these thoughts were displayed in a public place: the kitchen. Similarly people felt a tenderness (even a sympathy!) for those who simply messaged, in effect, ''think of me''. In other words, what we enabled with Homenote was intelligence of a kind, albeit sometimes sentimental. Smart homes should be as sensitive to this as they are to reminding, planning and other more functional types of tasks. After all, intelligence is not merely a matter of practicality; it is also a matter of affection.

5 Supporting family awareness: the whereabouts clock

Our next example leads directly on from our work around situated messaging in the home. Our studies of HomeNote made us realise that there was a place that could allow a variety of forms of expression, ranging from the tender to the functional. But amongst these messages it became clear that some, a particular kind, had a special value that needed protection for itself. This was not because these messages were notably valuable or rich, rather that their value derived from being seen at a glance in the place in which they were relevant.

In particular, the messages in question were related to the whereabouts of the sender. Here it turns out that where someone *is* lets them express something in particular, it is a statement of fact that in itself expresses meaning. Thus the fact that someone is stuck on a train might mean that the person in question is lamenting the chaos of the traffic system, but it also means, and this is more salient to those in the home, that that person is

likely to be late. This is of importance to the recipient of this information, because of where *they* are. It can mean that they might adjust their plans for eating, for example, or that they avoid worrying about the due arrival of their spouse or offspring. The whereabouts of people turns out to be a useful piece of information in the home for those doing particular things in the home.

It is in light of this that we built a device called the *Whereabouts Clock*. This allows family members to observe the whereabouts of other relatives, using a coarse-grained representation. Figure 6 (left) shows a screenshot of this initial prototype with three broad location categories identified as "Home", "Work" and "School". The middle of the circle identifies when individuals are travelling between locations, or are in an unregistered location. Icons identify individual family members, these moving between categories to reflect changes in physical location. Our current implementation uses the identification of nearby cell towers to detect, at a loose approximation, where individuals are. Groupings of cell towers are mapped onto these high-level human interpretable categories. A SmartPhone client (Fig. 6, top right) scans for cell towers in proximity and sends updates via SMS to the situated surface when people cross over these mapped boundaries.

The Whereabouts Clock was designed to exploit the home's particular physical and social arrangements, with the intention that intelligence might come about through how it was readily incorporated by householders and not its technical sophistication. First, and perhaps most obviously, the surface is intended to be *situated* in the home rather than remotely accessible or mobile. Although this is obvious, it is worth noting that the information this surface displays is designed for recipients in a particular place. The display is also intended to be *always on*, continually available for people in the home (and specifically in the kitchen) to view. This is not because we think this information is so important that it is needed 24 h per day, but because its persistent availability means that it is there, whenever it is needed. A surface such as the one on the Whereabouts Clock offers visual information *persistently* and does so through being *at-a-glance*. Hence people at home can engage with it in much the same way as they might glance at a table to see if mail needs to be attended to. But, in being separate from other places where various types of information might be located, the utility of this information is made greater. Location information is important, but only to the extent that it can be seen without effort. The Whereabouts Clock reflects this.

We have as yet to trial the Whereabouts Clock either in the office or in the home. Whatever its fate, the fact that it is a situated display may be important in addressing some of the concerns around privacy found in the literature on location tracking. With our device, only people located in a particular place can view location information. These people are in the home and are therefore subject to its constraints: determining *who* can see (by dint of access rights to the house), as well as *when* they might be able to see (by dint of when people ought to be in the house), and so on. The result of this is that, by design, sensitive information is *only* broadcast to other trusted family members. This is not to say there are no privacy concerns around such a surface. There may be instances when family members prefer to be selective in revealing their location or activities to others. Teenagers, for example, may prefer not to have location information automatically pulled, but would rather push this information to their parents at select times to reassure them, or they may be happy for their parents to know they are in town but would rather not reveal their specific location in a bar or club. We have therefore deliberately selected a high level of granularity of the location information in question. In this sense, we have tried to attain a level of "intelligence" that is appropriate for the home, given the nature of the need for the information, and the type of people who have access to it. Intelligence is as much about where you can find out about something as it is about what it is you know.

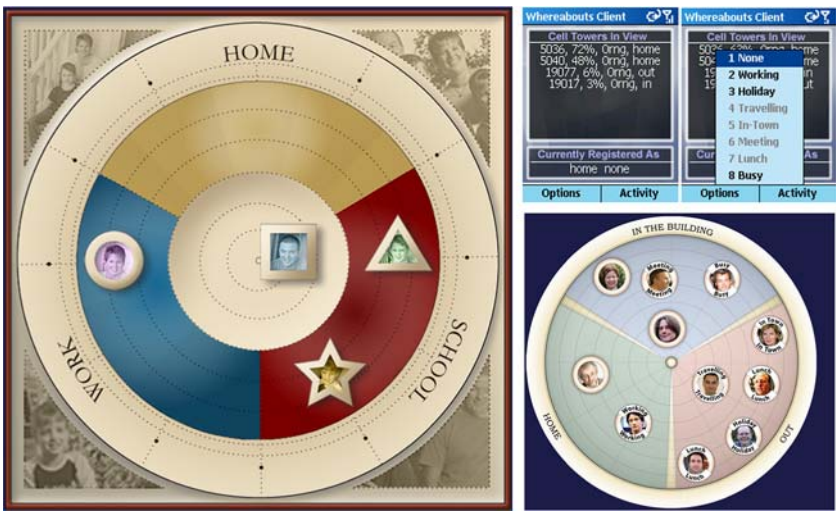

Fig. 6 One particular design for the home version of the Whereabouts Clock (*left*), office version (*bottom right*) and SmartPhone client (*top right*)

6 Media containment: the picture bowl

The final example from our studies is of a seemingly persistent feature of family households, which would not seem to have much to do with surfaces. After having our attention drawn to a series of bowls holding a collection of miscellany in a household we were studying, we became intrigued by the different ways people collect, store and manage *clutter*. The prevalence of clutter in family homes seemed to recommend it for study if only because of its near ubiquity. As we began to delve into this topic, we also began to see how surfaces of a kind might be leveraged to offer new ways of dealing with clutter. To get to this point in our thinking, though, requires us to take a look at what clutter might be.

Clutter is made up of a variety of things: things temporarily out of place, things with limited life spans, things with ambiguous sentimental value, things in transition and things that no one knows what to do with, to name a few. By its nature, clutter in family homes is particularly heterogeneous because it represents the detritus of all the various family members. In and amongst a family's clutter, one finds functional things like glue, rubber bands, tape, lumped with children's broken toys, old sentimental items that do not quite deserve a place on the mantle piece, and so forth. Similarly, there are coupons, batteries, and chequebooks sitting alongside what might be seen as the quintessential item of clutter, keys that belong to no obvious keyhole, but no one dares throw out.

People deal with clutter in a variety of ways. They enlist bowls and drawers, dividers, tubs, plastic bags, and all sorts of categorization methods (or hardly any at all). How people in families choose to divide and store their clutter varies, as does the amount of effort expended, but what remains consistent is the use of artefacts that physically contain. The trouble with clutter, as we all know, is that it can spread out; bowls, drawers and the like keep it together, contained.

Although clutter is often treated in an off-hand way, it is evident that where containers like bowls and drawers are situated in the home does matter. And this returns us to our concern with surfaces, to the idea that where things get put, what things, when and how, is a measure of the human intelligence in a home. Here, though, this intelligence relates to being tidy, being, as it were, organised sufficiently that the home does not submerge under chaos. This is a kind of intelligence, which is also (on the other hand) not so organising that it becomes a burden. One can be intelligently lazy after all.

It is possible to imagine a smart home automatically sorting and dealing with clutter in the ways we have described. The premise might be that a task that requires just a little bit of forethought and intelligence could be done away with and given, so to speak, to the building. From what we have seen, we believe that such a solution would encounter all sorts of problems. It is evident, for instance, that the allocating of certain sorts of stuff to clutter bowls, drawers and so forth, is a thoughtful activity, where subtle judgements are made about stuff that may have no immediate place or certain "home". To be sure, some of it might eventually be given somewhere to go, but a lot of clutter sits in the bowls or drawers waiting until time and a little sentiment move it along, perhaps to another bowl or a drawer, or sometimes to the rubbish. Thus, however intelligent a smart home might be, it is in the very nature of clutter that a proportion of it can not be sorted out, that it remains ambiguous.

If this seems reasonable, it still remains some way from the design of technology. "Some things do not have places to go: so what!" one can hear the smart home designer say. But this is to miss the point that an intelligent way of dealing with the uncategorisable is required in the home. Stuff like keys for unknown locks is one thing, but it seems to us that, at a time when members of homes increasingly carry all sorts of digital devices, the amount of digital clutter they bring home is increasing, too. We think smart home designers might ignore this clutter at their peril and, though they might prefer to ban it from their smart homes, a solution for dealing with what one might call *digital clutter* is required.

Currently, the established solution for handling the proliferation of digital media (e.g., digital photos, video, music, etc.) centres on the pc. The pc serves as a "hub" to peripheral devices designed to capture and play digital media, devices such as still and video cameras, MP3 players, PDAs and, increasingly, mobile phones. There is, undoubtedly, much to recommend the PC as a destination for digital media. It offers a common interface to store, organize and manipulate digital media, and gives users the ability to perform a number of sophisticated editing procedures. Seen from our perspective on the use of bowls and drawers, the PC, however, does not present an easy, low effort method for dealing with digital media. Rather, it offers what one might say is too much, an unwieldy piece of intelligence that does not reflect the casual storage and loose organization that clutter deserves—even of the digital kind.

Take, for instance, the burgeoning use of media-enabled mobile phones. The content on these phones is not necessarily captured, stored, shared and occasionally cherished for its quality or to use in later editing. Instead, the quickly snapped photos or shared video are retained, temporarily or possibly for longer, primarily as a way of augmenting the lived experience of any moment in time [10, 14]. Accordingly dozens of images are taken during a day, most of which have no value after they are shown. Some, for a variety of reasons, may have value but this might not be immediately obvious nor something that the person who has taken the images wants to decide upon there and then. Instead, a common practice with mobile phone content is that images are kept on the device until their owner is forced to make a decision. This decision takes the form of either downloading onto the PC or deletion. In our view, the PC option is a step

too far. The question then is what would a reasoned alternative to the PC be? It seems to us that what is required, instead, is a solution that reflects how images on phones have clutter-like properties. They consist of a mixture of stuff, some that has no value and some that does. What is needed is a way of putting this stuff somewhere temporary, which is what we have being trying to devise.

Drawing on ideas we have developed from our study of clutter, we have attempted to determine what physical properties enable the low-effort storage of clutter. As a point of comparison, our thoughts on surface ecologies have been instructive. For example, it has provoked the question as to why do bowls and drawers afford the practices we have described above, as opposed to other places one finds in the home? Why are floors or stair landings not the sites for clutter? The answer is obvious, but we will restate it: stuff needs containing.

Second, the idea of an ecology of surfaces in the home helped us recognise that *where* a clutter bowl is situated can afford something particular: its placement can reflect a site where clutter may be ''properly unpacked''. Bowls in entranceways to the home, for example, succeed in their rolls as containers for keys, chequebooks and the like because that is where those things spew forth from pockets and raincoats. Again, we return to the moral order of the home, to when and where it is acceptable to do things like place and amass clutter. Bowls and drawers, placed in particular locations, offer just enough to deal with clutter as it arises. Situated as they are, in the right place and at the right time, bowls (and indeed other containing devices) allow for an intelligently low-effort method of maintaining order.

Our studies also made us reflect on the fact that bowls display at least some of their content, which means that what is placed in them is visible to everyone in a house. So, whilst bowls contain, they also reveal; passers-by, as it were, can see what they are for and be reminded of or use their content. In these ways, the placement of bowls, the way they display clutter, makes the organisation of tidiness tractable. It may be a form of idleness that leads people to throw things into a bowl, but it is an intelligent way of dealing with the problem (of clutter) in home settings.

With these points in mind we have designed the *Picture Bowl* (Fig. 7), an augmented bowl that exploits how bowls ''work'' and further enables simple and lightweight actions for viewing and holding digital media. Still at its concept stage, we plan for our Picture Bowl to allow physical and electronic devices to be placed in it and their content to be displayed in the form of thumbnails on the sides of the bowl. As more devices are added, existing content will be ''pushed'' towards the bottom of the bowl. In this way, the Picture Bowl will provide a sense of sidedness and depth—in essence a place to contain. We also propose that content can be copied to the bowl by simultaneously holding a collection of thumbnails with one finger and removing the associated device, simulating a peeling-off like effect. This operation could offer a low effort solution to shedding content, for instance in an entranceway bowl as one rushes out the door with a digital camera. The possibility of this stands in stark contrast to the efforts needed to upload content to a PC and being immediately directed into an environment where one must engage with it.

To support the ''glanceability'' of content in bowls, we also envisage thumbnails being slid up the Picture Bowl's sides and ''attached'' to its top edge by using a finger. This could allow specific media to be left for passers-by to see, possibly offering a subtle, visual reminder for some action or event. Last, but not least, we imagine the bowl being portable making it possible to be situated in various places. Ideally, a home might also have multiple augmented containers that could be situated to support different uses. This would allow, for instance, problems of privacy to be dealt with in a common sense fashion. People could place personal containers in private places like the bedroom and thus privacy would be managed through the social ordering of the home and not through the cumbersome and arcane use of passwords and access rights. A portable device would also allow media to be moved from one place to another. Thus content might be brought to an augmented tabletop where it could ''poured'' onto the

Fig. 7 Current manifestation of *Picture Bowl*. Two data projectors project media thumbnails onto the opaque glass surface and DirectShow's VMR and Direct3D are used to visualize the media. We anticipate using a combination of Bluetooth and RFID to identify individual devices and transfer content. We also intend to touch-enable the bowl, incorporating either a flexible transparent capacitive overlay or image processing techniques

larger flat surface and organised, shared or deleted. This would further harness the properties of different surfaces, making the most of bowls for containing and the flat horizontal surfaces for activities such as sharing and organising.

7 Conclusion

And thus, in a roundabout way, we have come back to the beginning. Our idea is that surfaces in the home are places where the intelligence of people in the home is marshalled, displayed, leveraged and worked upon. People use surfaces in intelligent ways to do a variety of things. Not all of these things are of equal merit nor do they achieve equal ends. For example, the ways in which people use fridge surfaces shows how some things matter more than others; how some things will matter tomorrow but not today; and how other things do not matter at all and yet are thoughtfully placed there for everyone to see.

One could approach this diversity as a problem, one that computers could help solve. The smart home programme, as we see it, has been preoccupied with elaborate technologies to monitor human movement, the comings and goings of occupants, and has sought, for example, to link this movement to various messaging systems. According to this vision, the smart home could check who is in the kitchen, say, and alert that person to various messages or to-do-items related to their being in that place.

Though this vision sounds appealing, to us it is misguided on two counts. First, and this is the weakest objection (though nonetheless a powerful one for that), we conjecture that this vision will be too difficult, both technologically and in terms of its usability. Replicating the complexity of the real world would make the system complex and vulnerable to error; it will almost certainly make it difficult to use. We would expect the burden of entering data into the smart house to be far greater than the benefits that come out of it.

A stronger objection, from our view, has to do with what one might call the balance between human and machine in this vision. This alludes to a particular take on what intelligence might mean and imply. It seems to us that the way people deploy their thoughtfulness at home is by steering a course between two opposites: mechanized routine on the one hand and relaxed, unplanned and almost chaotic behaviour, on the other. For example, to send a good morning message to one's partner as they walk in to the kitchen each morning will soon become meaningless and irritating if done every day, mechanically. Tenderness between people in the home is suffocated by routine, yet the opportunity for tenderness is squeezed by the practical requirements of living at home. There are always tasks to do, things to plan for, and the daily grind of ''housework''. This would suggest, then, that a solution could be found in mixing the routine and the novel, the effortful and the relaxed in different ways. Accordingly, every person and every household is different in precisely the ways that each chooses a particular course between these opposing goals. Their choice makes each home unique. Our view is that we should design technology that allows people to make the decisions as they see fit, and to reflect what they value on any particular day. Thus it is up to individual members of a household to send a note to say they are thinking of someone else; it is a matter of personal choice when, and indeed whether, the digital clutter in their bowls gets sorted out.

Certainly, we want to make some of this easier for them, not in the sense of reducing the burden of choice, but in making choices clearer to judge and easier to see. To be able to see at-a-glance that some one is still at work means that an individual can choose either to delay dinner or give the person still at work a call and urge them to hurry home. This sort of technology is not offering intelligence, it is only offering people in homes further resources to act and think. It is this thinking, in the hearts and the minds of the occupants, that should make a home smart and not the technology embedded within.

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