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## Pervasive computing in the domestic space

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**Abstract** Information and computing technologies have gone wild; broken free as servants of organizational ends and launched off the desktop, computing artefacts are finding new forms, new rationales and new circumstance of use. In some cases this change is purposeful and deliberate, but in others an intriguing socio-technical drift is at work, and the influences over that drift are yet to be understood. Here, we surface four interrelated dimensions along which transformation is occurring (technology, context, users and purposes), and we commence a discussion aiming to articulate both the visible and the unremarked upon influences over that drift.

**Keywords** Domestication · Pervasive computing

### 1 Introduction

Why would the pervasive computing community be interested in the domestic space? What sorts of pervasive technologies are beginning to inhabit our homes, and how are our homes, and the lives lived therein, changing under the influence of that technology?

In 2003, Richard Harper [1] released the edited volume *Inside the Smart Home* and noted in its introductory remarks that smart homes “have not been a hit because they have been too expensive, the housing stock is old, there has been a tendency for little networked connectivity, and finally there has been too much technology push, and little attention given to users and usability”. It remains striking today that few if any

smart homes have been inhabited in anything more than merely hobbyist ways, and that our stories about their use rest on such slim empirical foundations. It is further striking that technology is arriving in the home in ways that do not accord with our current and shaky ideas of what a smart home might or might not be.

Earlier in 1999, Debbie Hindus [2] called technologists to action, inciting them to take the home and its inhabitants seriously as an opportunity for technology research. The gap remains today. Lots of great technology research published in the AI, intelligent buildings, pervasive and ubiquitous outlets, a great deal of interesting domestic research in sociology and cultural theory that is fiendishly difficult to apply to technology research, and some merging and genuinely design oriented ‘domestic technology’ work in the CSCW and HCI camps. But the work on pervasive technology in domestic settings is fragmented, and its researchers need to be adept in the literatures and methods of many disciplines. This slim collection is intended to help with consolidation by viewing technology firmly in domestic settings, by re-examining the concept of the home in radical ways, and by examining the extraordinary range of human activities that occur in the environments in which we are born, dwell, rear families, and eventually die.

### 2 Themes

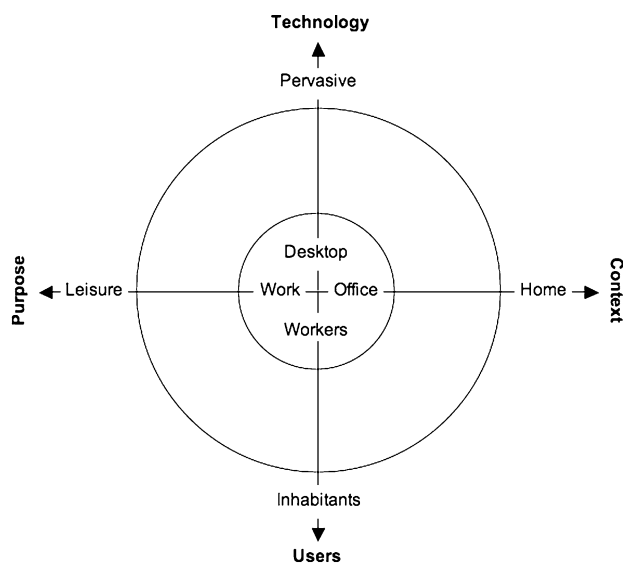
The ongoing evolution towards pervasive technologies in domestic settings is neither simple nor uni-dimensional. It is not just about the invention of new technologies or about existing technology being brought to use in new settings. In the articles of this special issue, at least four interrelated dimensions can be identified along which researchers and designers have been stretching our understandings, and our practices, as they relate to technology and the home. For the sake of better terms, we will refer to these interdependent dimensions as technology, context, users and purpose.

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Technology forms are in flux, extending beyond the desktop to include mobile and situated devices, and first generation pervasive and ubiquitous computing for the home. In this special issue we consider these technology forms, and their place in the home. Historically, our disciplines have focussed, almost to the exclusion of all else, on the organizational context of IT. Here, our interest in context is confined to domestic spaces, albeit in their many different forms. Our user focus moves us away from workers engaged in productive labour, towards inhabitants and the habitation of domestic spaces. Finally, our activity focus stretches beyond merely work related purposes, to include everyday life, leisure and play. As a simplistic illustration, Fig. 1 depicts the various shifts that this special issue pivots around.

Common to all papers in this special issue is that they represent a change of focus along one or more of these dimensions. Palen and Hughes examine parents' (primarily mothers) use of mobile phones in parenting and managing the intersection between work and domestic life. Haines et al. study family members' everyday use of appliances in the home, for carrying out the domestic duties that assist homes function. Nagel et al. study mothers' use of instant messaging in the home for supporting communication within the family. Bell and Dourish discuss males and their attachment to, and appropriation of, the shed. Taylor et al. study families with children, using situated displays in the home in order to support presence awareness and keeping in touch. Zafiroglu and Chang examine retired people on the road in their mobile homes (RVs), and their integration of office and domestic technologies with connectivity and positioning technologies. Garnæs et al. study strong tie partners' use of personal handheld



**Fig. 1** Transiting along the dimensions of technology, context, user and purpose from a traditional focus on desktop computing in the office supporting workers doing work to a focus on pervasive computing in the home supporting inhabitants' leisure time

devices in order to support distributed and intimate exchanges. Terrenghi et al. study families' use of digital video technology in the kitchen, and in so doing redefine cooking as a social event of shared experiences and learning. In the interview with Steven Kyffin, Vetere and Feltham discuss a shift from task-oriented to 'being-oriented' technologies, and argue that a vocabulary is needed for reconsidering the home, and its associated methods.

Of course, the four dimensions illustrated in Fig. 1 are neither complete nor orthogonal, so readers will see other important themes emerge from the papers. Other themes include methodological (both research and design) considerations, e.g. how to conduct empirical research in such private spheres, how to engage with participants over extended periods of time, how to creatively and systematically design for 'future practice' rather than fix the problems of current practice, and how to evaluate the quality of novel technologies, and against fuzzy measures such as pleasure, nourishment and playfulness.

In the papers of this special issue, methodological considerations are prevalent—though in general not a primary focus. Palen and Hughes apply a diary approach extended with SMS prompting of questionnaire fill-out to learn about mobile phone use over time. Haines et al. extend cultural probes with "missions" to provide a more focused dataset. Nagel et al., Bell and Dourish, and Zafiroglu and Chang each apply variants of ethnography to technology use in situ. Taylor et al. deploy working prototypes in peoples' homes and study real-world use over time. Informed by an earlier cultural probes study, Garnæs et al. use paper prototyping for iterative experiments with new form factors. Working with technology installations, Terrenghi et al. study the use of functional prototypes. Finally, Vetere and Feltham use a practitioner interview to elicit several years of industrial experience with the design of home technologies.

In the sub-sections below, we take a closer look at the four themes of moving off the desktop, out of the office, away from workers and away from work, and relate the individual papers of this special issue more closely to these themes.

## 2.1 Technology: from tools to 'not-tools'

During the last decade, ICTs (in particular desktop technologies) have played enormous and significant roles in the workplace. Since their introduction in the mid-1970s, personal computers now support a wide range of work related activities, and are indispensable in most organizations. In the workplace, technology is a tool that is time saving, useful, precise, and accurate (see Table 1 for a thematic juxtaposition). Technologies have penetrated the domestic space with different purposes, and most households in the industrialized world contain one or more personal computers. In the home, people

**Table 1** Thinking about tools and not-tools

Artefacts as tools	Artefacts as not-tools
Time saving	Time using
Useful	Pleasurable
Precise and accurate	Ambiguous and playful

use desktop computers to search and browse the Internet, chat through instant messaging, play computer games, buy online, and pay bills through home banking etc. Falling purchase prices for consumer electronics and the introduction of broadband connectivity have contributed to this adoption profile.

While technologies in the home can act as tools (e.g. paying bills), domestic technologies are frequently ‘time using’ in nature, e.g. game playing and entertainment. Further, homes are characterized by technologies that are off the desktop. Inhabitants apply and use such technologies in many everyday situations for washing clothes in a washing machine, cooking food in a microwave oven, controlling the television with a remote control, or accessing the home through intercom systems etc. Often people interact with some of these technologies seamlessly as they are rather well integrated into our daily routines and they are viewed as appliances providing tailored functionality. In a sense, we are moving from tools to not-tools, from desktop like artefacts to domestic artefacts that support less instrumental activity.

Our disciplines are becoming sensitive to technologies that are highly pervasive, ubiquitous and ambient. Obviously many of these off the desktop technologies provide rather different means of interaction. The prevailing metaphor of technology for the office, i.e. ‘the tool’, may not catch the breadth of forms and applications that we will see in the domestic space.

This special issue contains papers ranging from traditional desktop to pervasive technologies. Some of the papers apply traditional desktop technologies to support various family activities (Nagel et al. for availability prediction, Bell and Dourish for viewing the home from the shed, Zafiroglu and Chang on the use of technology in recreational vehicles, and Terrenghi et al. on video based recordings of and for food preparation). Other contributions are primarily concerned with mobile technologies (Palen and Hughes on parenting using mobile phones for managing work and private life and Garnæs et al. on supporting intimate co-habiting couples in staying in touch). Yet other papers deal more directly with pervasive and ambient technologies (Taylor et al. on situated displays for flexible communication in the home, Haines et al. on domestic appliances for the future smart home, and Vetere and Feltham on ‘being-oriented’ technologies).

## 2.2 Context: from places of work to places of ‘not-work’

Historically, the disciplines of human–computer interaction (HCI) and computer-supported cooperative work

(CSCW) have emerged from a focus on computer use in places of work. Although labelled ‘personal’ and increasingly situated in peoples’ homes, the desktop computers of the 1970s, 1980s and even 1990s were not as much for personal use as they were for supporting work related activities. Hence, the term “desktop” computing is associated very much with a place of work, whether in corporate or home office settings, rather than within a place of ‘not work’. When we brought the desktop computer home it was not called “couch computing”, “recliner computing”, or “coffee table computing”. Although computing began penetrating our homes, the home computer mostly did so as extensions of our places of work. Within the last decade, this has changed dramatically. Home computing is now much more about leisure than about work, and hence computer technology is truly diffusing into places of not-work—lounges, kitchens, bedrooms, and sheds.

Places of work are very different from places of not-work and hence shifting our focus from places of work to places of not-work imposes a series of new challenges for technology and intersection design (see Table 2 for a thematic juxtaposition). Whereas our places of work are passed through and professional, our places of not-work are usually lived in and personal. Places of work are furnished and configured to be effective and useful. Our places of not-work are set up to be cosy and relaxed. Places of work are for achieving, competing and taking risks. At places of not-work we relax, recover and take refuge.

Our special issue mostly contains papers focusing on technology use in places of not-work but some papers also focus on the use of personal technologies (i.e. private mobile phones) to manage the overlaps and intersections of places of work and places of not-work. We present papers examining the use of information technology and computerized appliances in the home for supporting communication and domestic duties (Haines et al. and Nagel et al.). Looking at more specific places of not-work, we present papers examining technology use in kitchen settings for family communication and sharing of social experiences (Taylor et al. and Terrenghi et al.). We also present papers broadening our perspective of domestic places of not-work by examining technology use in rather unconventional settings (Zafiroglu and Chang on retired people on the road in mobile homes, and Bell and Dourish on the appropriation of office technologies in the shed). Managing overlaps and intersections between work and home, we present papers examining parents’ and partners’ use of personal communication technologies (Palen and Hughes on mobile

**Table 2** Thinking about offices and homes

Places of work	Places of not-work
Passed through	Lived in
Effective	Cosy
Risk, compete, achieve	Refuge, recover, relax

phones and parenting, and Garnæs et al. on supporting intimacy while physically separated).

### 2.3 Users: from workers to ‘not-workers’

The notion of ‘user’ seems to be quite mundane, and excessively instrumental when we consider the rich, gentle and sustained lives lived by domestic inhabitants. Users in workplaces adopt roles that are typically well defined and focused. As an example, nurses and doctors in a hospital acquire the same kind of codified knowledge, through formalized educational and training programmes. Further, they take up roles in the hospital that are well defined in terms of what they are allowed and not allowed to do. In contrast, the roles and responsibilities of inhabitants of domestic spaces are rarely explicitly defined. Inhabitants rarely receive a formal and systematic education that enables them to interact with domestic technologies, and domestic practices. They can be seen as a much more diverse population, including the very young and very old. Inhabitants acquire knowledge on domestic practices, and their related technologies, through a complex enculturation process that extends over long periods of time.

Whereas workers often represent the middle majority of a population (e.g. on age or skills), inhabitants also include extremes at the ends of the curve (see Table 3). For instance, the HCI field is currently focusing more and more on issues related senior citizens and children and their use of technologies. Thus, pervasive and ubiquitous computing technologies in the home will be asked to accommodate inhabitants with specific knowledge and perhaps limited skills (e.g. cognitive, behavioural) as well as inhabitants with more advanced skills. Also, we have now established a tradition of viewing people interacting with a computing technology as users of that particular technology. But this concept may not be the most appropriate for people in homes who are primarily inhabitants of those homes, rather than users of the technology. This observation could challenge the way designers approach interaction design for domestic technologies and could potentially change and inform our understanding of who we design for, and how we design with them.

Our special issue contains papers that exemplify and illustrate the tension between user and inhabitant. We present papers ranging from co-habiting couples desiring to stay in touch (Garnæs et al.) and male users of sheds (Bell and Dourish) to intergenerational family communication and coordination through situated dis-

plays (Taylor et al.) and family reflections on future technologies in the smart home (Haines et al.). The special issue covers papers on aspects of parenting that focus primarily on mothers as ‘users’ of mobile phones for managing work and private life (Palen and Hughes) while others investigate mothers’ potential use of instant messaging to predict family availability (Nagel, Sungn and Abowd). Along the way, we also consider certain roles and activities in the home, e.g. cooking as an activity for family learning and archiving (Terrenghi, Hilliges and Butz) and users in mobile homes that are retired and pursuing leisure tourism (Zafiroglu and Chang).

### 2.4 Purpose: from acts of work to acts of ‘not-work’

Work is done in domestic spaces; children are collected from school, groceries are purchased and carted home, elderly relatives are visited, sometimes reluctantly by younger children. Families are coordinated and corralled, they cooperate and are sometimes uncooperative. Add to this ‘family work’ the blurring of the boundary between home and paid employment, between work and leisure, and the need to take seriously the work done at home (made all the more possible with the advent of domestic computing, mobiles and domestic networks) is ineluctable. And yet, that is only a partial insight into the human activity that plays out inside our domestic spaces.

Our disciplines (e.g. HCI, CSCW, information systems, social construction of technology) have been imbued with ways of thinking about work (see Table 4 for a thematic juxtaposition). Workful activity is goal oriented, it can be measured in terms of efficiency and effectiveness. Perhaps above all else it serves a greater, productive purpose—work is not done for the sake of doing work. We do not set out to ‘have work’ in the sense that we ‘have fun’. Much family activity is difficult to conceive of in these terms, where the goal may be as diffuse as ‘passing the time’, where the actors involved could not themselves identify anything as having been ‘produced’ during this interval, and yet the yield from activities such as passing the time goes towards defining the very identity of the family, and often remains with the members of those families for the rest of their lives. How might we conceive of human activity in the home that falls outside of traditional goal-oriented and productive conceptualizations of endeavour, with their concerns for the ‘efficient transmission of accurate information’?

**Table 3** Thinking about workers and inhabitants

Workers	Not-workers
Middle majority	Ends of the curve
Trained	Enculturated
Explicit reward and ‘development’	Implicit rewards and ‘growth’

**Table 4** Thinking about work and non-work

Acts of work	Acts of not-work
Ends over means	Means over ends
Productive	Consumptive
Efficient	Nourishing

Our special issue contains papers that range across the topics of work done at home and the work of the home (e.g. Terrenghi, Hilliges and Butz on the work of the family kitchen), considerations of the dutiful aspects of family life (e.g. Palen and Hughes on mobile parenting, Nagel, Sung and Abowd on smart availability services), and discussions of the domestic activities that remain when work is abstracted out of the landscape (e.g. interview with Steven Kyffin). Along the way we reconsider the meaning of the home itself by viewing its boundary examples (i.e. Dourish and Bell on garden sheds, and Zafiroglu and Chang on mobile homes (i.e. recreational vehicles). We stop in to look at research methodology (e.g. Haines et al on domestic probes) and take a look at some suggestive concepts for future technologies (e.g. Taylor et al and Garnæs et al).

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### 3 Concluding comment

Each of the papers appearing in this special issue offer an absorbing insight into where homes are and where we

as a community might take them, as our understanding of the multitude of technology supported human goings-on that they enclose increases.

The special issue commences with an interview with Steven Kyffin from Philips. We then present six long papers, which draw out many of the underlying themes and issues relating to the domestication of pervasive computing. We conclude with two technology sketches—provocative suggestions for the future.

Taken together the contents of this special issue sketch out a fascinating and rapidly changing territory, and we hope contribute in some small way to a humane domestication of computing technologies.

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