Finding a Place for UbiComp in the Home

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Abstract. The movement of design out of the workplace and into the home brings with it the need to develop new analytic concepts to consider how ubiquitous computing might relate to and support everyday activities in domestic settings. In this paper we present a number of concepts derived from ethnographic studies of routine activities and technology uses implicated in the production and consumption of communication in the home. These concepts sensitise design to the importance of the ecology of the domestic space and distributed arrangements of collaboration to communication. They draw attention to the places where communication is accomplished and the routines whereby communication is articulated, thereby highlighting 'prime sites' for situating ubiquitous computing in the domestic environment.

1 A New Challenge

The domestic environment is currently receiving a great deal of attention as a place for the development of ubiquitous computing. The technical and methodological challenges involved in realising computing systems for the domestic environment are significant, and require researchers to anticipate facilities that are likely to emerge in the home of the future. Anticipating the future is fraught with difficulties and researchers have tended to exploit purpose built 'living laboratories' in order to explore both the future potential and the shortcomings of current technological infrastructures, and to consider the ways in which inhabitants might experience the home of the future [3, 13, 15]. These explorations have been complemented by design led 'visions of the future' [18] that seek to convey the potential ways in which ubiquitous computing might be deployed in domestic settings. The home offers new sets of challenges that move our understanding of interaction beyond the current focus on information and knowledge work. It exposes us to the demands of new user groups, including the elderly, the disabled and the mentally impaired [14, 5], and requires us to be sensitive to the impact of broader cultural values and the need to support activities other than work [7].

A key research problem in designing for this environment is the need to understand the everyday character of the home: how people live in the home, what they do when they are at home, and the potential role of technologies within the milieu of domestic activities. This paper is concerned with the social character of the domestic

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environment, particular with regards to communication which is a prime area for design [11], and with developing a sensitivity to the real world, real time ways in which communications are produced and consumed in the home in order that ubiquitous computing might be woven into and resonate with domestic activities [23]. While there is a vast literature on communication in the workplace, when we turn the home we find few conceptual and analytical tools to assist design [10]. Furthermore, it has been suggested that in turning to familiar concepts derived from the workplace there is risk of migrating and operationalising a set of values that may be inappropriate for domestic design [8]. Indeed, as Gaver puts it,

> There is a danger that as technology moves from the office into our homes, it will bring along with it workplace values such as efficiency and productivity at the expense of other possibilities. (ibid.)

The problem here is that such things as 'production' and 'efficiency', which may themselves be construed of in terms of such concepts as 'plans and procedures' and 'workflow' along with a host of analytic concepts that describe the organization of practical action in the workplace in terms of Fordist and Taylorist principles of capital production, do not apply to the organization of practical action in the home. This is not to say that household members do not have a concern with the production of domestic life or with efficiency in carrying out household activities, early research in the field suggests that they do [23], but rather that such things as production and efficiency in domestic life cannot be adequately understood in the accepted terms of capital production, as domestic life is not organized in those terms by household members. The home and workplace are *different* domains and we do not need an extensive period of research to tell us that – as members of society we know that, and as designers we know it as a condition of our inquiries. The problem we have is not one of understanding that the home and the workplace are different, then, but of developing insights into how and in what ways the home is different in order that we might develop technologies that are appropriate to the setting.

Accordingly, this paper presents and articulates a number of analytic concepts that sensitise ubiquitous computing to the organization of communication in the home environment and open up the play of possibilities for design. These *sensitising concepts* have emerged from a series of ethnographic studies of domestic settings and are elaborated through the explication of an empirical instance of the collaborative production and consumption of communication in the home. We exploit the notion of 'traffic' as a guiding principle and consider how the primary social organizational features observed in members practical management of traffic may be exploited to develop domain knowledge and inform the development and placement of ubiquitous computing in a wide variety of domestic settings. We employ a distinct representational format to convey the overall results from our studies and to articulate a set of key properties that may be explicated by other researchers in other settings. Following this, we outline a number of challenges for ubiquitous computing to emerge from our research. First, however, we briefly consider the motivating factors behind our work, which have given rise to a distinct set of sensitising concepts for ubiquitous in the home.

2 Developing an Understanding of Technology in the Home

We offer a set of concepts sensitising design to important features of social activity and technology use in the home by reflecting on a series of ethnographic studies of the production and consumption of communication in domestic life. These studies focus particularly on what Edwards and Grinter [6] call,

> … the stable and compelling routines of the home, rather than external factors, including the abilities of the technology itself. These routines are subtle, complex, and ill-articulated, if they are articulated at all … Only by grounding our designs in such realities of the home will we have a better chance to minimize, or at least predict, the effects of our technologies.

Concurring with this position, we reason that design may be usefully informed through careful consideration of the ways in which existing technologies, whether technically sophisticated or not [25], are routinely made to be 'at home' by household members in their everyday interactions so that they come to assume an eventful and purposeful role in domestic affairs [20]. A number of ethnographic studies have already offered rich insights into the routine nature of domestic life and technology use in the home [16, 24, 26, 22]. While such insights promise to open up the design space and inform the design of computer-based technologies that support the day-to-day functioning of the household, there is a need to move beyond the particular studies of a small group of social scientists to provide conceptual and analytical tools that designers in general may employ.

Two key principles derived from previous work in the field [17] underpin the stance we have adopted in moving from the particular to the general and developing conceptual and analytical resources that ground design in the routine character of domestic life.

- Routine activities are socially organized through household members' interactions with a host of technologies distributed throughout the home, and which support the coordination of action in their use.
- The distributed character of the technologically mediated 'work' of coordination highlights the central importance of the ecology of domestic space for design.

When considering these issues, our particular interest lies in articulating the distribution of technical objects or 'media' and their placement in various shared locations around the home in relation to the flow of information involved in communication and the coordination of practical action [9]. We have exploited this point of view when studying the domestic routines implicated in the production and consumption of communication in order to identify a set of key features or properties to inform the development and placement of ubiquitous computing in the home. In the following section we present the key social organizational features to have emerged from our studies, which articulate the ways in which communication media are routinely 'made at home' by household members.

3 The Social Organization of Communication in the Home

The sensitising concepts presented here emerged from a series of long-term ethnographic studies of 22 family homes across England that began in May 2001 and are ongoing. Our concern with communication came from two principle sources.

- It was evident from our initial studies that a great deal of activity in the home is concerned with communication *coming into* and *going out of* the home, and that many of the information resources and technologies in the home are implicated in communicative action.
- Communication has been one of the major areas of development in computing generally and provides a key motivator as design moves out of the workplace and into the home [11].

To complement our broader set of studies where communication emerged as a general and pervasive issue within domestic settings, we undertook three highly detailed and focused studies of communications in three different family settings in order to develop a more coherent understanding of communicative activity and its social organization (i.e., to develop a better understanding of how incoming and outgoing communications are produced, managed and consumed). The studies actively involved the participants. Rather than have an ethnographer 'hang around' the home, we asked our participants to video communications coming into and going out of the home and to keep a log briefly describing where the communications occurred, what they were about, who was involved, and what was done in response to particular communications. This strategy had two distinct benefits.

- It meant that the ethnographers did not have to spend long periods of time waiting around for events of relevance to the research to happen. Over a one-week period during the study, incoming and outgoing communications took up around one and half to two hours of video tape. More time was spent on communication though the details were not always recorded, and understandably so, because of a variety of sensitive household matters. Nevertheless, the approach produced a rich corpus of quality data and was highly cost effective.
- Enlisting participants as data gatherers provided the opportunity to open up a highly detailed and intimate dialogue with household members. The video and logs became conversational resources which we used to explore the social organization of communication in the home in collaboration with those parties who actually do the 'work'. The approach enabled us to involve inhabitants in a design dialogue and to bring their competences to bear on design reasoning then.

Recognising that ethnography is nothing more, or less, than a data collection technique, we adopt an ethnomethodological approach to the *analysis* of ethnographic materials [4]. Ethnomethodology is concerned to explicate the social organization of activities in observable details of their local production by members, rather than in the more conventional terms of social science theory. Accordingly, we examine empirical instances of communication in theoretically unmediated detail in order that we

might see what can be seen and learn what can be learnt of communication in the home as real world, real time socially organized activity.

3.1 An Instance of the Social Organization of Communication

We present a simple empirical instance collected during our studies, which should be seen and treated as an *illustrative* case that enables us to articulate key social organizational features of communication and sensitising concepts.

Dave arrives home from work and on entering the porch picks up the day's mail. He walks into the kitchen and sorts and opens the mail. One is a postcard from family members who are on holiday and one is a 'thankyou' card from a friend who stayed over at the weekend. Dave puts the cards at the front of the kitchen table for Jane to see when she gets back from work.

Fig. 1. Receiving and placing a card for the attention of others (porch and kitchen table)

Dave then goes into the living room and starts his computer, sending an email to the card sender to acknowledge receipt of the card and exchange similar sentiments.

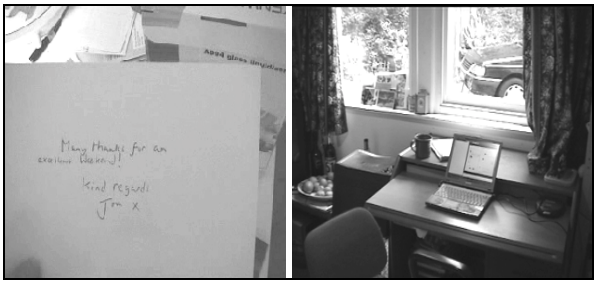

Fig. 2. Responding to the card (email from workstation in living room)

When Jane arrives home (some four hours later) she notices the cards on the table. Jane picks them up, walks into the living room where she sits down on the sofa and discusses both the weekend and family members holiday briefly with Dave. Jane then puts the card on the mantelpiece in the living room and the postcard on the windowsill.

Fig. 3. Places where cards live (the mantelpiece and windowsill)

4 Key Features and Sensitising Concepts

> **traffic** n. & v. **4** dealings or communication between people etc. **5** the messages, signals, etc., transmitted through a communications system; the flow or volume of such business. The Concise Oxford Dictionary

Treated as an illustrative case, the above instance draws our attention to several grossly observable features of communication in the home. In particular, the instance instructs us that a primary feature of the production and consumption of communication in the home is a members' concern with the practical management of *traffic* in and through the domestic space[1]. In this context it is worth noting the diversity of media used within this simple act of communication and the ways in which household members coordinate the use of a range of media as a practical part of this act. Fig. 4 represents the ecological distribution and diversity of media used in this instance.

The point of this representational *format* is not simply to represent the traffic implicated in individual instances. Rather, the purpose is to enable designers to 'get a picture' of the social organization of communication in the home as a single coherent environment. Accordingly, the role and importance of the ecological distribution of traffic and the sites at which various media are used becomes even more apparent when we consider a number of instances of communication in tandem. Fig. 5 represents communications traffic in the same household over a one-week period.

4.1 Places of Communication

The collection of instances represented in Fig. 5 moves us beyond recognition of the spatial (and temporal) distribution of communication [17] to make a phenomenon available to design reasoning that has not already been seen in the single instances, namely, the social organization of communications traffic as a whole. What emerge

[1] This view contrasts with conventional reasoning which suggests that the primary feature of communication is social cohesion [e.g. 11, 12]. Our studies do not deny the important *functions* of communication but rather, draw our attention to taken for granted organizations of communication upon which such weighty matters *rely upon or turn*.

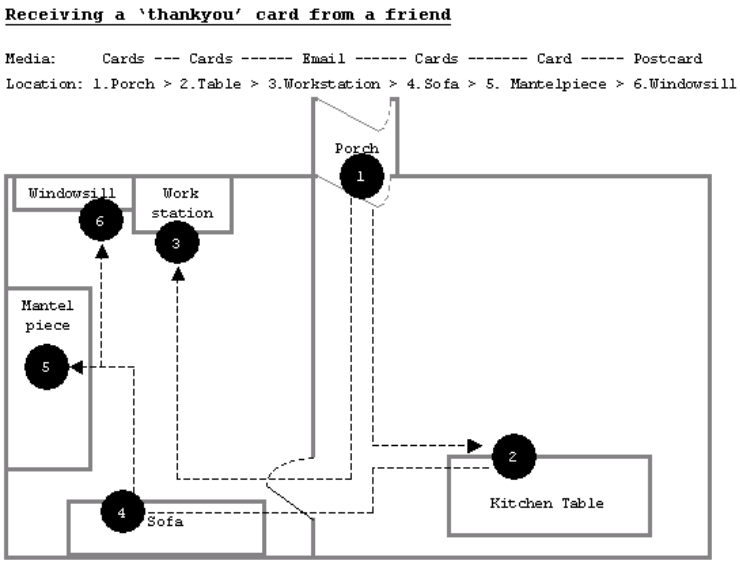

Fig. 4. Communications traffic within the home

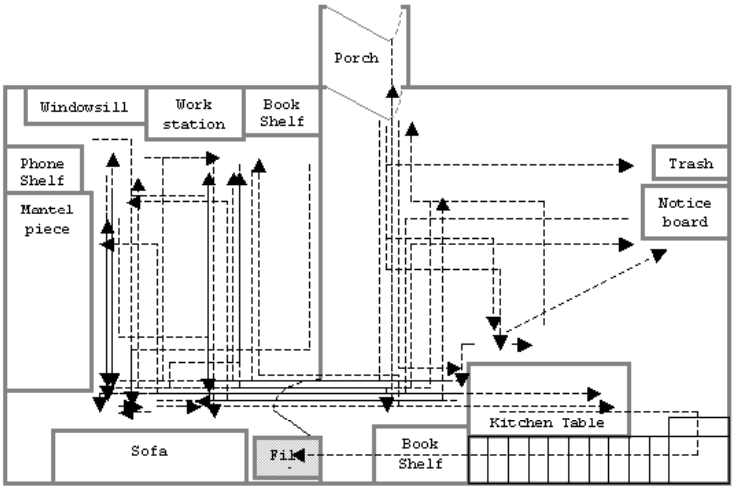

Fig. 5. Incoming and outgoing traffic over a one-week period

are patterns of technologically mediated activity and the reciprocal flow of communications traffic around the home. Thus we see traffic flow from familiar *place* to familiar *place* in the home. In the rest of this section we consider the social organization of traffic in terms of the familiar places implicated in communications coming into and going out of the home. In particular, we consider three different, grossly observable properties of these places and there relationship to the production, management and consumption of communication. These include:

- **Ecological Habitats:** places where communication media live and where residents go in order to locate particular resources.
- **Activity Centres:** places where media are actively produced and consumed and where information is transformed.
- **Coordinate Displays:** places where media are displayed and made available to residents to coordinate their activities.

In the rest of this section we explicate each of these in turn, moving from textual description of the single instance to the representational collection in order to make the social organization of communication in the domestic environment available to design reasoning and inspection in other residential settings.

Ecological Habitats. One of the initial observations to emerge from our studies is that the various media implicated in communication live in particular places. Household members do not have to search for the mail, or the computer, or the telephone and address book, etc., because they *situate* communication media in particular places from where they may be readily retrieved or accessed when they are needed. As a rule, or matter of routine use, communication media live in particular places where they may be readily located. This, of course, is not to say that communication media do not stray, that members do not lose things. Indeed, such occurrences demonstrate the rule as it were and may be accounted for by invoking the ordinary notion of *mis*-placing things. More formally, we might call these places 'ecological habitats'. The term draws analytic attention to the physical surroundings within which communication media reside. Ecological habitats are readily available to observation. They are in plain view and require no special methods to see. In the case of our illustrative instance, the windowsill and mantelpiece are employed as ecological habitats (places where certain kinds of card live). The workstation (from where the responding email is sent), the kitchen table (where the card is placed for the attention of others), and the sofa (where the cards are used), each elaborate different organizational properties, which will be addressed below. First, however, if we consider the representational collection the following ecological habitats become visible across the home as a whole.

Each of these habitats was illuminated or made visible by a single instance (sometimes recurrently, where mail or the phone was involved for example) and through the use of particular media, which the single instance elaborates in detail.

Activity Centres. The places where communication media live (ecological habitats) are not necessarily the same places where communication media are used and our observations highlight this. The instances shows, for example, how on being noticed (through their placement at the kitchen table) the cards migrate to the sofa where they become conversational objects for Jane and Dave. We call the places where communication media are used 'activity centres' insofar as the collection of instances shows us that there are certain places in the home where communication media are recurrently employed. The collection of instances reveals the following activity centres in the study setting.

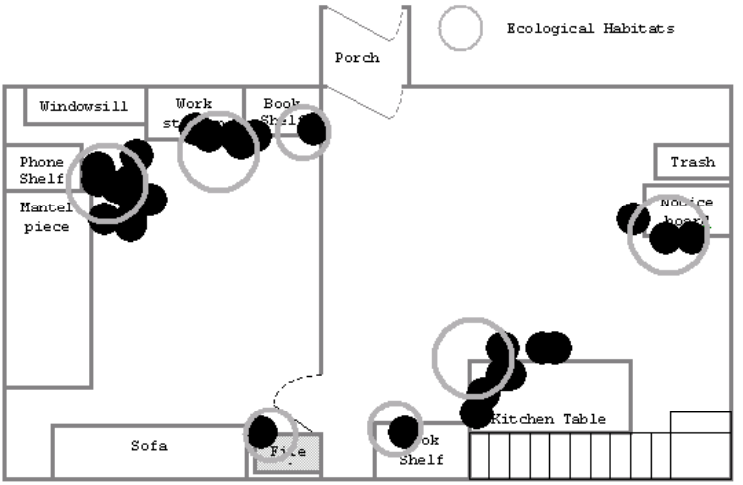

Fig. 6. Ecological Habitats (Phone Shelf, Workstation, Noticeboard, Kitchen Table, File, etc.)

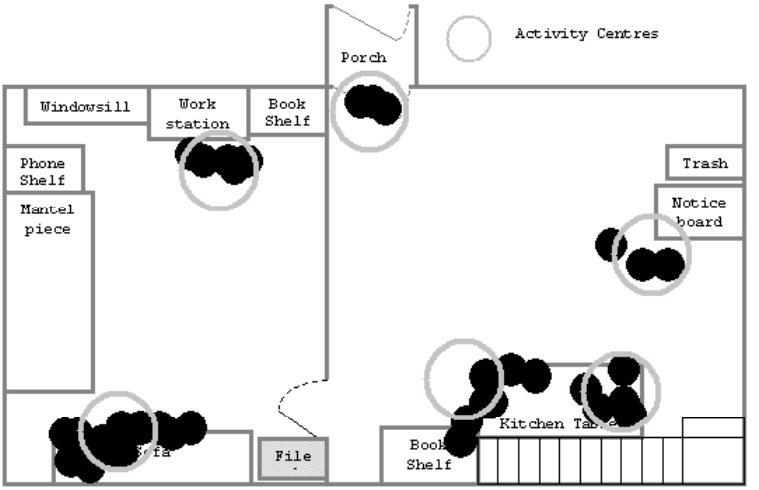

Fig. 7. Activity Centres (Sofa, Workstation, Porch Noticeboard, Kitchen Table)

Although distinct, some ecological habitats and activity centres overlap (see Fig. 6 for comparison). In this home, the workstation, noticeboard, and kitchen table are at different times employed by members to perform different roles. For example, the kitchen table is at one time a habitat for the handling of mail while also being a centre for conducting phone calls. The noticeboard is at one time a habitat for information of short-term relevance (appointment cards, concert tickets, school term dates, etc.) and at another a centre where the information situated there becomes a resource in social interaction. Similarly, the workstation is at one time a habitat where documents are kept and displayed as reminders of ongoing jobs of work and at another a centre

where emails are received and sent. This overlap is important for reasons that will be articulated in due course.

Coordinate Displays. Household inhabitants routinely construct displays from out of the flow of communication media. On receiving the cards, for example, Dave places them on the kitchen table for the attention of Jane, who subsequently places them on the mantelpiece and windowsill. The mantelpiece and windowsill are ecological habitats that are employed to display certain objects in this home and while interesting insofar as such sites provide a 'home' for future display technologies (such as electronic picture frames), what is of more interest to us is the construction of what we call 'coordinate displays'.

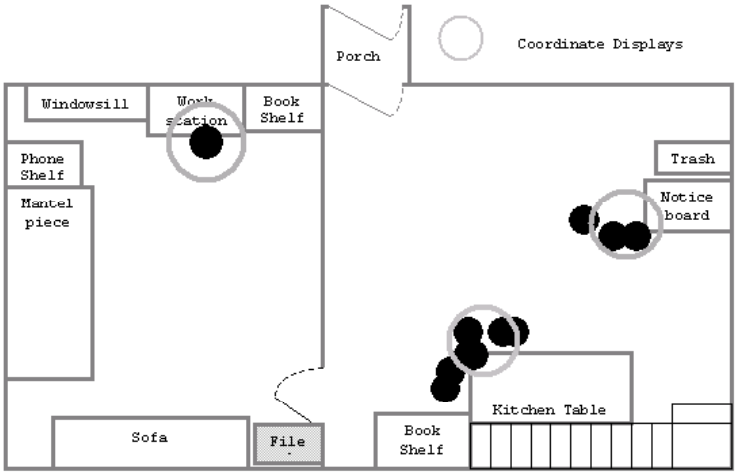

Fig. 8. Coordinate Displays (Workstation, Kitchen Table and Noticeboard)

The kitchen table provides us with a prime example of a coordinate display. The kitchen table is a tacitly agreed upon site between Dave and Jane for the placing of mail. Both know that incoming mail will be placed at this site. No words or discussion is needed as they can see at-a-glance that mail has arrived that requires attention by the very act of its visible placement and display. The important point about such sites of display is the rationale and function of their construction. The display of mail not only triggers conversation between household members as with the cards, but more importantly, it triggers practical action such as the timely paying of household bills, renewing vehicle tax or household insurance, for example, *not that the person who opens the mail is necessarily the who takes action*, however. In other words, the construction of displays at certain sites through the placing of mail (and other media implicated in communication) provides for the coordination of practical action. As is the case with ecological habitats and activity centres, these places are architecturally and aesthetically contingent. In other words, their specific location depends on the particular physical layout of the home and the arrangement of 'mobilia' or furniture therein. Just as some places may at one time serve as activity centres and at others as

ecological habitats, then so too they may also serve as sites for the construction of coordinate displays. For example, the noticeboard is at one time a place where information of short-term relevance is kept to-hand, at another a place where that information is employed as a resource in communication (coordinating family visits through consulting school term dates, for example), and at another time a place where the information placed there displays and so provides for the timely coordination of social activities (such as taking the children to a party, attending a dentist's appointment, or paying an invoice at the end of the month). Just what places overlap and serve multiple functions will depend on the particular residential environment under study.

4.2 The Flow of Communication

The various places outlined above only make sense as part of an overall flow of communication. A key property organizing the flow of communication identified in our studies is that of discrete and recurrent 'sequences of action'. Sequences of action consist of the routine courses of action and technology use that link the various ecological habitats, activity centres and coordinate displays together in any single instance. Dave and Jane's handling of the cards shows, for example, the recurrent ways in which such media are routinely handled in their home: through placing cards on the table and in different locations where they are used and subsequently live (see Fig. 4). Other instances in this particular home show how the handling of mail more generally is organized through the recurrent construction of coordinate displays at the kitchen table and noticeboard and how mail of long-term relevance migrates to particular habitats (such as the domestic filing system). Individual sequences of action *elaborate the social organization of particular forms of communication in particular settings*. For example, on getting up in a morning, someone might collect, open and read mail at-the-kitchen-table over breakfast, placing items to be dealt with later on the bureau-in-the-living-room and bills to paid on-the-trolley-in-the-hall. Sequences of action emphasize how information is spatially and temporally distributed throughout the home. They draw our attention to the particular ecological habitats, activity centres and coordinate displays implicated in particular forms of communication in particular settings and convey to designers the everyday routines of the home. The routines embodied in sequences of action are known to the inhabitants of the house and are used as a resource for managing their activities and for handling communication. Thus items to be 'worked' upon are placed within an appropriate and routine sequence of action. Thus, and for example, the packed lunch is left on the kitchen table where correspondence is opened and read in the morning, or beside the porch where household members may place various media to be taken to work. In the following section we consider the design implications to emerge from our consideration of the social organization of communication in the home.

5 Putting Sensitising Concepts to Work

Close examination of a corpus of empirical instances has enabled us to identify a set of socially organized features or properties that constitute a *system of communication*. Recognition of this socially organized system, and the ways in which inhabitants manage traffic through discrete and routine sequence of action that link various locations in the home together, provides us with a set of sensitising concepts that may be employed by designers to find a place for ubiquitous computing in a wide variety of residential settings. Obviously everyone's house is different - a broad set of architectural and aesthetic contingencies are involved in the layout of the home. Nevertheless, members of the architectural community have already highlighted stable ways in which people set up and configure the spaces they occupy. For example, work on patterns presents common arrangements [1], while work on the evolution of buildings highlights the underlying dynamics of change in the 'space plan' of the home [2, 19]. To complement these insights, the concepts we offer seek to convey the ways in which different ecological features of the home are exploited by members to manage and coordinate domestic activities. The point is not that every home will have a kitchen table and that bills are kept there in order that they can be found and acted on appropriately. Indeed, many homes may not have a kitchen table or may not even have a separate kitchen at all, especially in non-Western cultures. Nevertheless, we would suggest that *each home will have its own* ecological habitats, activity centres and coordinate displays that are constructed, arranged and linked together by household members in the course of carrying out the routine sequences of action whereby the produce, manage and consume communications.

Culture – whether understood in terms of nationality or age, gender, and identity, etc., is manifest in the routine character of communicative action in the home and the role of particular locations or places implicated in such action. In other words, 'culture' is not something separate from communication, something that stands behind it and shapes it as it were, but visibly implicated and manifest in its ecological organization. Accordingly, we suggest that there is a need for designers to be aware of the ecological character of communication and to chart the various places 'at work' in communication in order that ubiquitous computing might resonate with and so fit into domestic life in a wide variety of different settings. Such a sensitivity might be developed by conducting short periods of ethnography (whether through direct immersion of a fieldworker or the administration of household members) in order to gathering a corpus of single instances. These instances may be examined for their organizational properties:

- Firstly, for the routine sequences of action implicated in technology usage, no matter how technically sophisticated that technology may be.
- Secondly, for the ecological habitats, activity centres, and coordinate displays that are elaborated by routine sequences of action.
- Thirdly, findings may be represented to the design team through the use of the representational format to explicate the system as a whole.

Elaborating these organizational properties serves to convey a rich portrait of how communications are produced and consumed within a particular setting and orients the development team to a particular set of design concerns. In the following section we reflect on how the emergent concepts outlined above may be used to drive the design and deployment of ubiquitous computing for the home.

5.1 Placing Technologies in the Home

Considerations of the nature of the domestic space and the relationship and placement of technology therein is already of major concern to ubiquitous computing. Researchers have suggested that design will be required to develop a wide range of media spaces to support domestic communication [11]. Others have explored the integration of sensing technologies and digital services within the domestic space [13]. We seek to provide conceptual and analytic resources for the research community that will help guide the placement of ubiquitous computing to meet the routine day-to-day needs of inhabitants and so situate new and emerging technologies in appropriate places in the home. The need to integrate media spaces and digital services with the architectural and aesthetic fabric of buildings is emphasised by the notion of 'roomware' [21]. Roomware consists of such components as the *DynaWall* (an interactive electronic wall), *CommChairs* (mobile and networked chairs with integrated interactive devices), and the *InteracTable* (an interactive table). The relationship of new and emerging technology to the arrangement of domestic space has also been explored through the use of Pattern Languages and seen the emergence of the notion of *comZONES* [12]. As with roomware, this use of patterns is predicated on the integration of the digital into *new, purpose-built environments*. Consequently, it is not at all clear how existing approaches support the 'fitting' of technology into pre-existing environments in the piecemeal fashion that has been predicted for the adoption of ubiquitous computing in the home [6]. The sensitising concepts we have provided assist designers and help them to address this problem by orienting designers to the different ways in which particular locations are routinely employed and so 'situate design in the home' by elaborating the various places in particular environments that provide candidate locations for future technologies.

Prime Sites for Technology. One of the most obvious uses of the concepts we have provided is to highlight 'prime sites' for ubiquitous computing in domestic settings. Our approach makes visible the ways in which a host of technologies are ordinarily employed. This in turn supports the identification of the ecological habitats, activity centres and coordinate displays associated with a particular setting and so provides a resource with which to frame design. For example, it has already been noted that some ecological habitats, activity centres and coordinate displays overlap, as can be seen below.

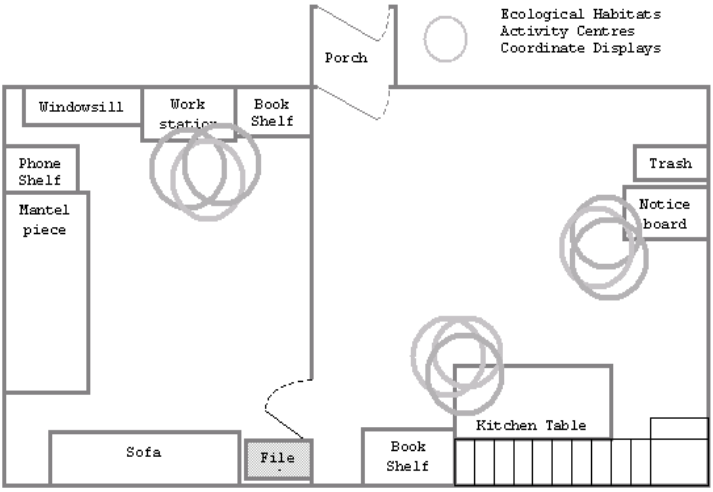

Fig. 9. What Place Might Ubiquitous Computing Find in the Home?

The places of overlap highlighted in Fig. 9 identify locations that inhabitants habitually exploit in the handling of communication. They draw attention to locations that users routinely return to in order to manage communication within the home and, consequently, identify places that offer good candidate locations for placing ubiquitous computing in particular settings. Their explication allows designers to reflect upon the nature of these overlaps within particular environments, contrasting the ways in which digital functionality is currently concentrated at the desk in the living room, for example, with the openness and flexibility of the noticeboard and the kitchen table to open up the play of possibilities for design. If we were to consider extending digital functionality across this household through the implementation of a *DynaWall* and *InteracTable*, for example, then the points of overlap elaborated above suggest that this would be best achieved by placing those technologies in the kitchen to create a network of digital services and surfaces manifest in locations that Dave and Jane habitually exploit to accomplish communication.

The Convergence of Media. Our concepts also highlight the diverse collection of media that are used by inhabitants in carrying out the daily routines involved in managing communication. In designing systems to fit into these settings we often need to consider the different forms of media that new technology will have to find a place alongside. Our studies suggest that rather than displacing existing media in the home, new technologies are used alongside a variety of different media that are employed across a range of different sites. The diversity of media involved in the household study reported here and the places where they are manipulated is reflected in Fig. 10.

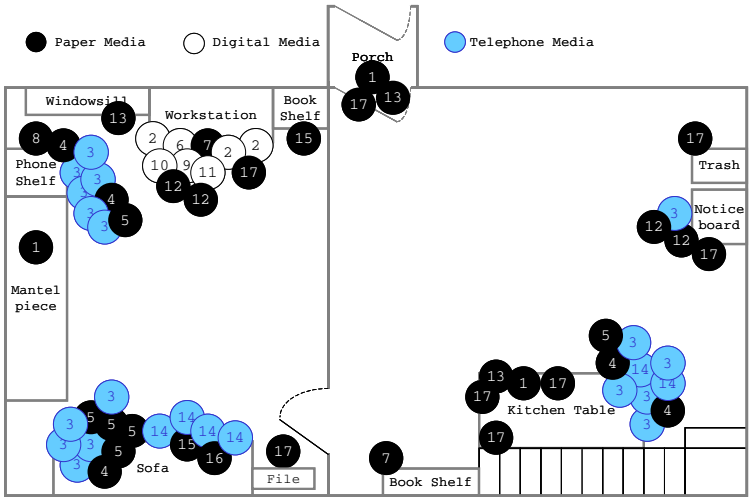

Fig. 10. Media Usage across Ecological Habitats, Activity Centres, and Coordinate Displays

Key to Fig 10.

1. Cards
2. Email
3. Phone
4. Address Book
5. Paper note
6. Internet
7. Paper recipe
8. Answer machine
9. Electronic documents
10. Hyperlinks
11. Digital images
12. Paper documents
13. Postcard
14. Text message
15. Book
16. Magazine
17 Mail (bills etc.)

Essentially, this representation draws attention to the various sort of media that coalesce at particular places and allows designers to pose questions as to whether or not they seek to supplement, augment or replace existing media. Furthermore, given the collection of empirical instances, this supports the making of design decisions with some definite insight into the ways in which new technology might impact upon current organizations of communication in the home.

More generally, this particular representation makes it perspicuous that paper-based media are well integrated into the home environment. Paper-based media can 'find a home' in any ecological habitat and coordinate display (they can be put in drawers, left on surfaces and pinned to walls). The means of creating and modifying them can be easily used in any activity centre (you can write and draw in activity centres throughout the home). Digital media, by way of contrast, are less comfortably integrated. Some, such as email, Internet and hyperlinks don't easily spread beyond the workstation, which is still required to produce, manage and consume them. To break this dependence, inhabitants often transform digital media to paper by printing them out. They also leave paper pointers to digital media, writing notes to remind others to read an email from a friend, for example. The mobility of devices may impact upon this. Telephone media are more widely spread throughout the home, for example. However, such mobile media still tend to cluster around but a few locations where they coalesce with other media (such as address books and paper notes), which suggests the need to *link* ubiquitous computing with other media at these places.

5.2 Building on Communication Places

In addition to raising a set of pertinent questions regarding the places where new and future technologies might be situated to meet the day-to-day needs of particular households, our research has provided a set of concepts that can be matched to existing and emergent research agendas. The three main features of places of communication provide a conceptual guide for more targeted investigation that combines more focused studies with different forms of technological development. Essentially, in just the same way that the concepts associated with the workplace (task, role, privacy and workflow, etc.) allowed researchers to develop research agendas within HCI and CSCW, then our concepts may be used to motivate and illuminate research questions in ubiquitous computing. In this section we wish to provide a brief illustrative example of research issues to emerge in our own work from each of the different features of place.

- **Ecological Habitats** are places where communication media reside. They are places where users return to find the resources needed to deal with communication activities. As we have seen in our studies, digital media currently tend to be closely connected with digital devices. In contrast, paper finds its way to a greater variety of places and uses in the home. What might it mean to make the digital more prominent throughout the home? How might the presence of various media - particularly non-digital media - be represented in ecological habitats to allow them to be digitally available? How might we mange issues of security and privacy when ecological habitats are made digitally available? These and a host of other issues, including the digital evolution of ecological habitats, represent interesting areas of future study.
- **Activity Centres** are places where media are manipulated, consumed and transformed. These places provide a key set of research issues regarding the augmentation of existing media used at them and beg the question as to what new forms of device may be developed for activity centres? Might we use electronic displays to augment electronic noticeboards or calendars, for example? How may a system represent the ‘work’ that goes on in activity centres to household members in order to support the management of activities within the home? How may a system make activity centres available at a distance, particularly from outside the home? How may a system exploit knowledge of the ‘work’ carried at activity centres and support access and privacy? Are sensing technologies a solution and do activity centres provide a guide to place video cameras and to guide video recognition to identify media uses and interactions that occur there?
- **Coordinate Displays** are places where communications media are made available to others in the domestic setting in order to support the coordination of activities. Primary research issues surrounding coordinate displays focus on recognising the events to be coordinated, and the various media implicated in coordination, to consider how these are best propagated throughout the household. It might also be important to consider how can we augment coordinate displays to make the information displayed available outside of the domestic setting? If so, the representation of

information and associated issues regarding the management of distributed collaborative access and control are important matters here and present significant challenges to the design of new technologies that merge the digital with the physical fabric of the home.

5.3 Exploiting Sequences of Action

As a final reflection we wish to briefly consider the routine sequences of action that elaborate and link ecological habitats, coordinate displays and activity centres together. These sequences are the means by which communication is handled and they articulate the sensitizing concepts we have presented. Designing technology to support sequences of action raises a number of questions, many of which arise from the limited penetration of digital media. Essentially digital media need to be more flexible in terms of how individual items are moved to and from ecological habitats, manipulated in different ways at activity centres, and placed to be seen by others at coordinate displays. Sequences of action raise distinct design questions regarding how devices may be used to support the distributed flow of objects and information around the home. For example, how might we assign email to various locations as with paper mail? Or again, how might personal devices be used to coordinate actions within sequences of action, enabling individuals to see and pick up email when it has been left in a public place for them? Sequences of action are not only topics for design, as it were, but also raise questions as to how they may be used as a resource within applications to support the overall management of communication in the home. This is a different order of question that shifts the focus from one concerned with the use of technology to one concerned with supporting the activities involved in sequences of action. Accordingly we might ask how we might exploit representations of sequences of action to make information available to others when it is most relevant? For example, might a system exploit the sequence of action associated with the principle bill payer to best *place* a reminder to pay a bill as he or she leaves for work? Or again, how might we exploit representations of sequences of action to monitor coordinate actions across the household, providing notification that a bill payment has been made by associating the payment with a prior sequence of action? These and the other questions articulated above open up a host of complex research issues. They may be explored in a range of different settings and further elaborated by other researchers through continued ethnographic study and the application of our sensitising concepts to the empirical materials gathered.

6 Conclusion

This paper has argued for the need for new conceptual and analytic tools to inform the development of ubiquitous computing as design moves out of the workplace and into the home. We have developed a set of sensitizing concepts from careful consideration of the empirical material drawn from a range of ethnographic studies of rou-

tine activities and technology uses in domestic settings. These concepts makes visible the socially organized production and consumption of communication in the domestic environment and sensitise design to the importance of the ecology of the domestic space and distributed arrangements of collaboration to communication. In particular, they draw design's attention to the key properties of ecological habitats, activity centres, and coordinate displays. Through routine sequences of action these are the places where communication 'gets done' and where a host of different communication media are manipulated and used. They highlight 'prime sites' for the placement of ubiquitous computing and elaborate a set of design questions informing the development of existing and emerging research agendas. The concepts we have presented are currently being employed to understand the unique requirements of a variety of very different homes, ranging from family environments to residential care settings, and to determine the functionality to be provided by new technologies as they are placed in a number of homes.

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