Domestic Hypermedia:
- Folding Hyperspaces into Households

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ABSTRACT

This paper analyses the use of media and material in private homes based on empirical studies in a project on designing interactive home environments. Material in homes with hypermedia characteristics includes photos, music, play-lists, as well as physical media such as newspapers, messages and letters. Based on the analyses we propose a Domestic Hypermedia infrastructure (DoHM) combining spatial, context-aware and physical hypermedia to support collaborative structuring and ubiquitous presentation of materials in private homes. With DoHM we propose establishing new relationship between digital and physical hyperspaces, folding hyperspaces into the physical space of the household. Thus we strive to combine the qualities of physical domestic materials and spaces with the flexibility and dynamics of digital hyperspaces. The DoHM infrastructure may be utilized on a variety of new ubiquitous home appliances called MediaWall, MediaTable, MediaTray and MediaPort, which are discussed in the paper.

Categories and Subject Descriptors

H.5 [**Information Interfaces and Presentation**]. H.5.1 [**Multimedia Information Systems**] augmented reality; H5.2. User interfaces; H.5.4 [**Hypertext/Hypermedia**]

General Terms

Documentation, Design, Experimentation, Human Factors.

Keywords

Ubiquitous hypermedia, domestic technology, multimedia, physical hypermedia, augmented reality, context awareness.

1. INTRODUCTION

We currently see an increased digitization of domestic material. Photos, movies, calendars, recipes, notes, banking, messages from school etc. increasingly become digitized and thus no longer have an inherent physical form [29]. Historically, the workplace has undergone a similar transition. However, the home is quite different from the workplace in many respects. Activities in the home are less task-oriented [24]; the rationalities of work in terms of production, efficiency and organization of labor do not necessarily transfer to the home [6]. Moreover inhabitants continuously re-configure and appropriate their homes both to express their identity to the outside world [26], but equally to capture their own history and biography [31] below. Thus homes have their own aesthetics where the visible, physical "information material" often play a role in expressing identity e.g. in terms of the books being read or the music listened to by the inhabitants. These qualities of the domestic environment are important to understand when designing hypermedia for the home.

Thus in order to design future domestic hypermedia systems, we argue that it is necessary to study the characteristics of the existing use of both physical and digital materials in homes today. While we are not the only one to take this point of stance, our focus is different from other studies. E.g. some groups have focused on understanding patterns of domestic routines ([6],[5],[32] below) where we have focused more broadly on eliciting the different roles domestic information materials may have, not restricted to patterns of routine. Others have investigated what constitutes the home experience [8] more generally, but this study did not reveal how specific materials formed part of constituting the home experience. Our studies are inspired by the studies by [6][5], who investigate how the physical space of the home is used to coordinate the handling of paper mail, but our focus is on materials more broadly than paper mail.

Emerging Domestic Technologies

Currently digital technologies spread rapidly in private homes, and there is a potential application area for hypermedia technologies. We see a convergence between digital and analog media in the home. Examples are PCTV, augmenting the PC with TV capabilities, and digital set-top boxes augmenting the TV with PC capabilities. Wireless LAN based gateways are becoming widespread [16], giving families internet access via portable computers everywhere in the home environment. Wireless home servers (like Amitech's eHome [1]) allow families to store documents, digital photos, video clips, etc. for common access.

Newspapers, radio and TV news are supplemented and partly replaced by Web news on computers or combined appliances as mentioned above. Traditional TVs will be replaced by plasma, projectors, and LCD TVs allowing high quality merge of TV and Computer displays. CD and DVD players become Ethernet enabled (e.g. KISS [18]) supporting ripping of media for storage on connected home servers as well as playback of typical internet

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music and video formats like MP3 and DivX. The ScreenFridge (www.electrolux.com) a refrigerator with built-in computer has been introduced to the market 5 years ago, and Philips are introducing a combination of large wall displays and smaller TabletPC like appliances for information access in private homes.

However, these technologies do not per se handle the challenges of supporting the organization of home materials, nor do they support a collective understanding and handling of materials. The focus of this paper is to bring this into focus in the design of future domestic technologies.

Hypermedia concepts relevant for the home

Research in spatial organization of digital information is of particular relevance to the domestic domain. From the hypermedia domain spatial hypermedia (e.g., VIKI [21]) which supports a big 2D space (a canvas) for sorting information or organizing brainstorm notes is a source of inspiration for domestic hypermedia. 2D spatial hypermedia supports a kind of organization by allowing items or "cards" to be generated and placed on a "table" (space). Cards may be tailored by changing their size, shape, color, or other visual characteristics. We have in a related project about architectural work brought this approach into 3D in the Topos system [4][23]. However, for the domestic hypermedia system we choose to utilize a simpler 2D spatial hypermedia support, since there is no inherent need for 3D in the domain

Open hypermedia [10] is another source of inspiration since the home similar to many work domains are characterized by being populated with a lot of different media which are not well suited for embedded structures. In particular we see a need for the ubiquitous open hypermedia systems, that deals with context-awareness (e.g. HyCon [2]) and augmentation of the physical world (e.g. the Topos Physical Hypermedia [10]). These context-aware hypermedia systems may be tailored to the home environment in order to support seamless context-dependent presentations for the inhabitants moving around in the home. The physical hypermedia approach may be tailored to the home environment in order to maintain relationships between physical material like souvenirs and digital photos, equipment and manuals, CD-covers and MP3s etc.

The Domestic Hypermedia (DoHM) infrastructure proposed in this paper combines elements of the above types of hypermedia systems into a framework for ubiquitous hypermedia for households. The work behind this paper is conducted in the iHome project which is hosted by the Center for Interactive Spaces (www.interactivespaces.net). The Danish HiFi and TV manufacturer, Bang & Olufsen is the industrial partner in the project.

The paper is structured as follows: Section 2 describes a qualitative approach to the study of 6 different types of households and section 3 outlines the challenges identified in this study for the design of domestic hypermedia. Section 4 introduces a domestic hypermedia infrastructure (DoHM) which seeks to meet the challenges identified in section 3. Section 5 gives examples of appliances, which fold hyperspace into the physical home environment. Section 6 discusses related work. Section 7 concludes the paper.

2. EMPIRICAL STUDIES

In the following, we describe the approach taken in studying domestic hypermedia and we provide examples of the information materials which exist in private homes.

2.1 Approach

We have undertaken qualitative empirical studies in six private homes inhabited by different types of families, ranging from singles, over families with children living at home, to communes. We visited each household once and stayed for approximately one and a half to two hours each place. In each home, we asked the inhabitants to take us on tours around the house [28]. We focused on how people organize domestic information materials in general, i.e. media, letters, memo lists, newspapers etc., and we interviewed people about the rationale, and history of the physical placements of both physical and digital materials. We asked about ownership and possible conflicts around placement of materials [25]. We captured data from the homes through video recordings, and pictures. The six visits form part of a continued investigation into domestic technology use of our own [27],[19] as well as others ([6], [25]).

2.2 Information material in homes

Taking tours in private homes reveals a wealth of information materials with hypermedia qualities, which are literally distributed all over the house. Table 1 holds a non exhaustive list of domestic materials, which are grouped into categories with different characteristics. The purpose of this list is to illustrate the richness and heterogeneity of domestic materials, rather than providing an exhaustive and complete list.

Types of material	Example material	Characteristics
Media	Movies, music, pictures, books, news, magazines, games, news, computer applications	Carefully chosen, bought and stored Used for leisure purposes
Home administration tools	Calendars, memo lists, tickets, contact information, notes for other family members, letters from school, kindergarten etc	Ongoing administration Used as tools for coordination
Domestic task	Recipes, manuals, handbooks	Support domestic tasks
Manifestations of social life	Invitations, greetings, personal letters, jokes	Maintaining social relations Capturing history Used as decoration
Communication with official authorities	Letters from bank, bills,	Information push Often little affection towards material
Decoration materials	Pictures, souvenirs, seasonal objects	Capturing history Expressing identity
Work materials	Electronic mail, word documents etc.	Support work tasks

Table 1: The heterogeneity of domestic materials and their use

We do not wish to claim that the categories below are rigid and disjunctive, e.g. a calendar is also a manifestation of social life. The purpose is rather to illustrate that home contain a complex collection of various heterogeneous materials of very different nature. Material, which are kept for different purposes, e.g. calendars, messages from school, shopping lists support the practical coordination of home life whereas various media are consumed and used for leisure purposes. Media are also most often actively selected, bought and carefully stored, whereas letters of communication with official authorities are pushed regularly upon the household members. As suggested in the following, these different forms of information materials are also often treated quite differently.

One tendency, which we do observe across the different types of materials, however, is an increased digitization of domestic materials. This happens with e.g. music [29], photos, and letters from bank. This has both negative as well as positive side-effects. The mission of this paper is to learn how to take the best from both sides and combine into visions on concepts for future domestic hypermedia systems.

3. CHALLENGES TO DOMESTIC HYPERMEDIA INTERFACES

In the following, we illustrate how the context of the home provides new challenges to hypermedia structuring mechanism. While these challenges are specific to the domestic sphere, we suggest that they are fruitful provocations for new conceptions of hypermedia more generally, and thus are also worth investigating in other contexts.

3.1 Linking digital and physical material

The homes contain a number of implicit links between digital and physical material that are currently not well supported.

Figure 1: Left: unlinked digital photos and printed versions. Right: recipe printed from the web with printed URL on.

Taking the case of digital photos we saw an instance where digital photos from a wedding had been developed onto paper in order to distribute them to others, and to make a physical collection of the pictures. In this case, the co-existence of the digital and physical form is important, however, there is no direct link between the physical and digital versions of the picture. E.g. there is no easy way of tracing the digital version of a physical photo. The only means of creating a link is through annotating the physical and digital versions by hand. We saw no instances where this had happened in the homes we visited. We saw an example of this, however, with photos developed from negatives. As can be seen in Figure 2, time-stamps on post-its with regular intervals in both collections provided means for linking the composites together.

Thus our studies suggest a need for linking support between digital and physical material, allowing for the co-existing of forms, rather than supporting transformation between forms as suggested by e.g. Humble et al. [17].

Figure 2: PostIts with dates provides link between composites of physical photos and corresponding negatives

An additional example is the case of recipes printed from the web, right picture in Figure 1. Here we find a one-directional link from the printed version to the digital material. Again we see how the digital and physical versions co-exist in homes as the physical version is more robust in the context of the kitchen, than the mobile computer of the household. However, both when it comes to physical pictures and physical recipes there are problems with searching through the material for specific contents as this relies on the inhabitant to produce metadata or in other ways impose structure on the physical material. One of the people we visited explained that it was much easier to re-print the recipe from the web rather than trying to find the printed version in the unstructured collection of recipes.

Further, there are a lot of implicit links between physical materials in the home. E.g. Figure 3 shows an example where the picture on the notice board of the wedded couple is implicitly linked to a date on the nearby calendar.

Figure 3: Calendar and notice board in kitchen

The same holds true for the football match schedule on the notice board. While both calendar and football schedule may well be digitized and linked together in terms of dates, this would miss the important quality of notification through the persistent visibility, which characterizes physical papers on a notice board in a busy place of the home. Thus as discussed in the following, key to designing successful hypermedia support is to understanding the roles of different domestic surfaces.

3.2 Understanding domestic surfaces

Crabtree et al. [6] were among the first to spell out in details how the specific surfaces in the home designate certain meaning and serve to coordinate domestic life. In their study they focused on paper mail (ibid), and described how if for instance a letter is found by the porch, it suggests that no other person has dealt with it yet. Whereas if it is placed at the doorstep of the teenagers' door, it signals that it has passed some other household member,

e.g. a parent, who may have recognized a letter from the phone-provider and expects the teenager to deal with it. Confirming the studies of Crabtree et al., but focusing on domestic information materials more broadly than paper mail, our studies also suggest that the spatial layout of the home is indeed used to coordinate and structure domestic information materials, and thus is a resource in designing domestic hypermedia.

To indicate how different surfaces of the home have different meaning, some example characteristics are listed in Table 2 and examples from the homes are presented in Figure 4 and Figure 5.

Surface	Example material	Surface characteristics
Notice boards	Emergency phone number Prescriptions Pictures from a wedding Appointment with dentist	Information which is 'one click away' Contact information Notifications Memorable material
Table	Brochures from a recent visit in a theme park Mixed pile of childrens' book, adults' book, and unused wrapping paper Unfinished shopping list, commercials	Traces of earlier activities Piles awaiting further distribution in the home Mixed media activity spaces
Entrance hall	A book which need to be returned to the shop A hat which must be worn when leaving the home	Things to remember to bring along when leaving the home
Shelves	Collection of selected cookbooks, music CDs, computer games. Illegal games are kept in a closed cupboard. Only cool cookbooks are on display in the common-room. Less cool books are stored in a room where visitors do not normally come	Media collections. Not necessarily sorted optimally for searching or browsing but rather in terms of aesthetics, and in terms of what people wish to show to others.
Frames	Picture collages, posters, etc..	Staging of personal memory

Table 2: Examples of different surfaces and their characteristics

Figure 4: Left: Dining table with brochure from a theme park recently visited. Right: Mixed pile of children's' book, adults' book, and unused wrapping paper awaiting further distribution in the home

Thus as the list suggest, we also see how different places in the house have different meanings and are used to structure domestic information material. We also see how other interest than supporting browsing and searching come into play when placing materials in homes. E.g. as illustrated in Figure 6, only selected cookbooks are placed so they are immediately visible to visitors whereas the rest of the collection is kept in a place where visitors not normally come.

Figure 5: Table in Entrance hall with a pile of things to remember when leaving the house.

Figure 6: Left: Shelves in kitchen where selected cookbooks are on display. Right Shelves in home office, holding the other part of the cookbook collection.

This is an example of what Palasmaa has described as "Home is a staging of personal memory. It functions as a two-way mediator - personal space expresses the personality to the outside world, but, equally important, it strengthens the dweller's self-image and concretizes his world order" ([26], p. 6). As people behave this way, and their home become meaningful in this way, it is important to ensure that this is also supported in future domestic environments where domestic materials are digitized. The highly spatial distribution of physical materials onto a multitude of surfaces in homes stands in market contrast to what happens, as domestic materials become digitized and stored on a personal computer in the home. The PC essentially provides centralized and individualized access to digital materials. It lacks the spatial distribution, the persistence and visibility of physical materials on display in the home, as we see numerous examples of in our empirical material. Thus we need to learn from the qualities of physical material, which enable spatial information structuring in the home when designing domestic hypermedia systems. While it is possible to design for distribution of digital material in the home, surfaces in the home needs to be uniquely identifiable for future presentations, but currently people don't have unique names for their different surfaces in the home

3.3 Lazy structuring and sustainability of structures

As evident from the pictures in Figure 7, which are taken in the same home, the time invested in structuring material reflects relationship to material. On the left picture is a mix of different materials including bills and papers from the bank. Right we see a collection of carefully collected and indexed cartoons. This leads to concerns on the sustainability of structures in everyday life of the home as some structuring mechanisms impose more effort on the user than others. An example of this is a case, where a person started to annotate individual digital photos with names of persons

and places on pictures making this content directly searchable. However, the person who had explored this facility stopped after having annotated only a fraction of his collection, simply due to the conflict between the size of his collection and the time and effort in annotating individual pictures.

Figure 7: Pictures from the same home. Letters from the bank etc. versus favorite cartoons

An additional example of breakdown of structuring mechanisms is the problem of scalability. As when for instance the collection of cartoons in left picture of Figure 8 becomes too big to be browsed through in terms of author. In right picture of Figure 8 we see an example where the collection is being re-structured. Here we see three different classifications on the same material at the same time. One part is placed in labeled boxes in order to provide unique location identification for each magazine. The intention is to exploit peer-to-peer digital metadata on the magazines to provide computer supported searching and browsing.

Figure 8: Different classifications on the same material – in this case cartoons

Another part is still ordered alphabetically by author. Finally a third part consists of the most recent issues. They are piled waiting for the owner to find time and mood to place them in the new categorization. This is in no ways a unique case. In the homes we saw numerous examples of half finished structures. This calls for an open hypermedia approach to domestic hypermedia, and for supporting lazy structuring of domestic materials. An example of a half finished structures and lazy structure of the physical material in the home is the widespread use of piles as a structuring mechanism. All the homes we visited had piles. Piles of bank papers and official papers waiting to be filed in binders. Piles of books on the dining table, waiting to be put in place.

Figure 9: Piles as structuring mechanism in homes

Piles are not as unstructured as it may first seem thanks to the meaning of different surfaces of places of the home, as discussed above. Some are piles of heterogeneous material, implicitly ordered by date, as sedimentations of materials. Not an effective structuring mechanism for a fast search, but a mechanism, which with the least possible effort still put some structure on the material largely due to the specific location of the pile. The pile in the entrance hall in Figure 5 is not sediment. It is carefully selected stuff which must be brought when leaving the home etc. Thus the specific context of the pile provides an additional layer of meaning to the structure. A dimension which is lost, if most domestic material can only be distributed on one, digital desktop.

3.4 The structuring experience

While one way to be pragmatic with respect to everyday life is to support lazy structuring mechanisms, an alternative and complementary approach is to design for playful and engaging structuring experiences thus aspiring people to take time to impose structure on their materials. The structuring experience provided by traditional PC's most often consists of individual manipulation of pull-down menus and dialogue boxes. Given the nature of the home, it would be interesting to investigate how collective and more playful structuring experiences can be supported.

4. DOMESTIC HYPERMEDIA – FOLDING HYPERSPACES INTO THE HOUSEHOLD

The empirical studies showed a lot of different ways of organizing physical material in the home. However, collaborative spatial organization and persistent visual awareness of the material seemed to be common means for the handling of domestic materials. In this section we propose a hypermedia concept that supports these approaches to structuring digital domestic material. We propose a hypermedia concept where digital hyperspaces are folded into the physical space. The notion of folding is inspired by the work on foldings within architecture. In architectural foldings the idea is to create more dynamic and open buildings by folding rooms of one type in between rooms of another type, e.g. public spaces are folded into more private spaces and vice versa. As described by Lynn [20] below, folding employs neither agitation nor evisceration but a supple layering. In such a way, that the characteristics of the individual layers are maintained. "A folded mixture is neither homogeneous, like whipped cream, nor fragmented like chopped nuts, but smooth and heterogeneous" (ibid p.9).

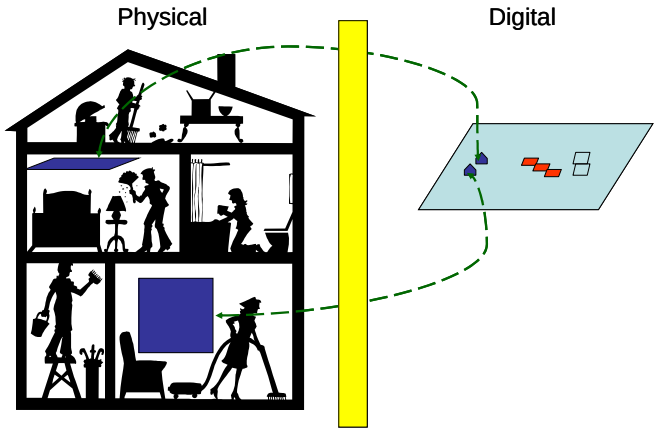

Figure 10: Folding physical and digital spatiality

We propose domestic hypermedia to fold digital spaces into physical spaces and vice versa in a way where the characteristics of both spaces are preserved, yet they are connected through layering. Thus we envision a multitude of digitally enabled surfaces in the future home. Each surface resides in a particular physical context, in the digital environment. The physical surfaces are represented by PlaceReps (place representations), which can be instantiated graphically or by a name, as depicted in Figure 13.

The folding consists in the parallel continuous presence of an abstract physical home representation in the digital hyperspace, and the physical representation of the domestic hyperspace through the interactive surfaces. The different "surfaces" may, with the current state of art, be TVs, projections, computer monitors, mobile phones, as well as HiFi equipment with only an auditory appearance. In the future, we envision surfaces to appear in more persistently visible materials like Gyricon [13] and eInk [8] paper, which is material allowing persistent display, also when the power is turned off. We may se a variety of ambient displays and controls [34] like wallpaper, bottles, RFID readers etc.

4.1 Domestic Hypermedia Infrastructure

The DoHM domestic hypermedia infrastructure (see Figure 11) is built on top of the open context-aware hypermedia framework HyCon [2]. HyCon is a context-aware hypermedia framework with a generic sensor layer that enables hypermedia clients to sense the context of users and devices registered in the framework. Moreover, HyCon supports XLINK structures, RDF, annotations, and WebDAV servers for collaborative handling of content and structures. HyCon among other things supports hypermedia composites utilizing XLINK.

DoHM is in particular designed to support folding of hyperspaces into the physical space. The empirical studies show that spatial organization and piling of material are very common structuring mechanism in homes as well as lazy or incomplete structuring is observed in many places. Thus DoHM in particular supports spatial hypermedia structuring integrating the connected physical surfaces as first class composite structures. The DoHM infrastructure also supports carrying digital material around both inside and outside the home by means of having a physical token (like a cell phone or a smartcard) representing a persons digital portfolio on the home server and other integrated servers.

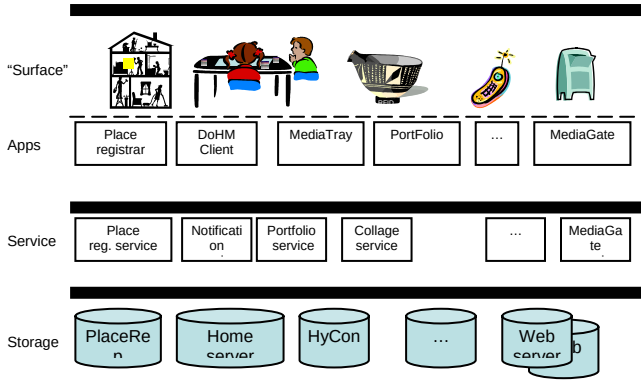

Figure 11: DoHM - Domestic Hypermedia infrastructure

The DoHM infrastructure is thus capable of handling the common structures that are used in homes, e.g. composites representing play lists, photo albums, and slideshows. Meta-data associated with physical objects or digital material like photos are represented in RDF. A central user interface for DoHM is the DoHM client, which provides a 2D spatial hypermedia interface including the registered surfaces as objects.

4.2 Modelling home surfaces

The various surfaces in the private home needs to be addressable from the point of view of the hypermedia system, such that particular material can be presented in different (or even multiple) physical locations in the home. As discussed in section 3.2 surfaces in the private home serve many different purposes and exist in different contexts. E.g. things to remember when leaving the home are places persistently and visibly in the hallway. Whereas peripheral awareness of earlier activities is created through the traces of material left on dining table.

This is implemented in the hypermedia model DoHM through adding two central concepts to the HyCon framework in order to handle representation and presentation. PlaceReps represent the place or context of a particular domestic hypermedia surface in the home; and PresStyles represent the style specification for a given object or surface.

4.2.1 PlaceReps

A PlaceRep is a class of objects in the system that represents the following information.

PlaceRep	
ID	Unique ID
Name	Surface name
Locations	List of Locations IDs
CollectionID	The composite presented on the surface.
DefaultPresStyle	Ref to PresStyle
DefaultAppearence	
…	

PlaceReps typically appear visually in the spatial hypermedia interface provided by the DoHM system and supports drag'n drop of material objects that in turn are presented visually, auditory or hapticly depending on the combination of the DefaultPresStyle and the object's PresStyle..

PlaceReps may represent both a specific place like "the refrigerator door" or an abstract place like "entrance" which may represent several physical locations in the home including, both hall, basement and terrace. Thus in this way, information that must be recalled when leaving the home can be displayed in all the physical entrances.

A Location holds the following information:

Location	
ID	Unique ID
Name	Location name
Coordinates	The physical location
DisplayType	Properties of the actual display
…	

The Location class is a simple extension of the HyCon location, where DisplayType is added.

4.2.2 PresStyles

In light of the different nature of the different materials and surfaces I.e. some material on some surfaces should be able call for attention in some context, e.g. the appointment with the dentist on the notice board, which must be remembered, whereas others need to be discrete and aging, e.g. pictures from a recent weekend trip with friends. Thus we wish to support the users in specifying different presentation styles for material and surfaces in the home. We introduce the PresStyle class to represent for the specific presentation style for a material object or a surface object.

PresStyle	
ID	Unique ID
Name	Style name
Specification	The presentation specification
Cascade	Priority
Script	Optional script
…	

Both surfaces and material objects may be associated with a PresStyle; this introduces the need for a combination strategy similar to the issues of Dexter Pspecs [14] and the cascade of Cascading stylesheets [7]. We wish to give the users maximum freedom in deciding how material in their home should be presented, to support the continuous appropriation of the home [31]. For instance, a teenage kid may prefer to have a certain skin PresStyle associated with the surfaces reminding her of a favorite movie on every surface in the room. On the other hand, parents may want to associate an intrusive red colored notification PresStyle with a reminder note that they place on every relevant surface in the home. :

PresStyle	**Material object**	**Surface**
Persistent	Object stay on top	Never go on standby
Aging	Object change appearance over time	All objects change appearance according to age
Collage		Collage objects according to a strategy specified in Script
Highlight	Object illuminated	
Surprise	The object appears occasionally	N/A
Animated	The object moves	All objects are animated according to a scheme specified in Script
Conditional Appearance	Object appear on surface under certain conditions	N/A
Context Sensing	N/A	The surface tracks all attached sensors and show results
Alarm	Trigger an alarm on an event specified in Script.	

In this case there should be a combination strategy that allows both the teenager to maintain her surface skin and to be notified about the important note from the parents. This is solved by a calculation of the cascade based on the cascade priority attributes of the involved PresStyles.

Based on the empirical studies we have identified a number of relevant PresStyle specifications to be supported.

The first four PresStyles directly follow from the way people organize themselves with physical materials in homes. The following explores the new possibilities opened up by having dynamic, context aware digital surfaces in the homes. The PressStyles will be subject to further experimentation and evaluation in an iterative design process.

5. Appliances utilizing the DoHM infrastructure

In this section we describe some examples of how the DoHM system may fold into the physical home environment.

5.1 MediaGates for piles of unsorted incoming material

The DoHM system provides client support for uploading of digital material and scanning of physical material to the home server. The gate hardware will typically be scanners (for paper), FlashRam or USB ports (for pictures and documents), FireWire ports (for video). But email, SMS/MMS messages may also be transferred to gate space. The material being uploaded will be dropped onto a “gate” folder and canvas acting as temporary space for unsorted incoming material. This gate canvas can be associated with places in the home, where the family wish to create awareness of recent un-processed material. One such place may be the dining table which in homes is often used as a gate area for physical material in transition into other places in the home, e.g. see Figure 4. In this way we may support the lazy structuring witnessed in homes, as seen in Figure 8 and Figure 9.

5.2 MediaTable: Augmented collaborative dining table

In many families, the dining table is a central place for coordinating activities, exchanging messages, and for organizing incoming materials. In the studies we have seen how families leave physical material on the dining table or the common room table creating a shared awareness in the home, before it is put away on a shelf or pinned to a notice board. When physical material becomes digitized it is often uploaded to or received on a computer somewhere in the home by one family member without reaching the attention of the rest of the family.

In a future home with many digital materials we wish to be able to support collective coordination and organization of materials similar to the physical case. We are thus designing the DoHM client to support e.g. a dining table to be augmented with top projection and direct tangible interaction. The DoHM client present itself to the user as a spatial hypermedia interface, implemented in SVG thus allowing PlaceReps, interaction elements and material objects to be turned around to be visible from arbitrary positions around the table, see Figure 13. The idea is that a common room table becomes a digital surface providing touch based interaction. The default view is the scratch area with

incoming material and visual icons for the registered PlaceRep objects.

Figure 12: A scenario with two people interacting around a MediaTable

In this way, family members become aware of new materials like incoming messages, new photos, new MP3s etc. Family members passing by can for instance drag a piece of material to a specific PlaceRep icon to make the material visible one or more surfaces in the home shown with the default PresStyle for these surfaces.

Figure 13: The DoHM client as it looks when supporting collaborative picture sorting. The icons on the left are PlaceRep icons for surfaces in the home. The floating toolbars contain tools for interaction with objects.

In a situation where the family gather in the living room they may sit down or stand around the table and sort the piles of recent pictures into folders on the home server and drag some of them to specific PlaceReps to have them rendered on specific surfaces. They may also associate specific digital material with physical objects by means of RFID tags as described in [10]. The objects may be printouts of pictures or souvenirs like a concert ticket or a kids' doll, which then becomes a physical link anchor for a picture or a collection of pictures. Thus the table also aim to support collective organization of material thus supporting new types of structuring experiences as suggested in section 3.4.

5.3 MediaTrays for physical link following

The DoHM client may fold out into the physical world as a display less MediaTray (see Figure 14), which can be used both as a normal tray and as an interface for activating links by means of RFID tagged physical material.

In the living room environment, a MediaTray placed on the sofa table may be used to start the playback of music on a connected HiFi set based on a physical object which has been associated the music. It may also be used to invoke a picture slide show on the TV based on a single printed picture being placed in the tray. In a kitchen environment a special MediaTray may be used to retrieve grocery declarations and recipes based on a piece of grocery material being put on the tray.

Figure 14: MediaTray for physical hypermedia interaction. The right picture shows the RFID tagreader in the bottom.

The MediaTray is a display less hypermedia interface; it needs to integrate seamlessly with the environment without having to be configured via menus and dialogs. Thus the MediaTray needs to take advantage of its context such as the nearest HiFi set, TV set or other surface. If the tray is physically moveable, it just needs to be registered to a new location, and then it automatically takes advantage of the new context, similar to the physical hypermedia system for architects discussed by Grønbæk et al [10].

5.4 MediaWall: Calm awareness support

In order to exploit the potential of surfaces in the home, we have developed the concept of the MediaWall.

Messages and notes often contain contents to be remembered and to be used at certain points in time. Thus some sort of notification service is needed, as when the appointment with the dentist must be remembered, as well as the time and place of a football match etc. However, few people wish to have there home filled with notifications in terms of active alarm clocks. In contrast, the MediaWall offers the quality of persistently visible message which is preferred in many cases. We reserve alarms to mission critical events like getting up in the morning.

Maintaining awareness about important material or critical events is supported in the DoHM system. Here we will focus on the discrete or calm [33] awareness based on discrete visual appearance. We are inspired by the notions of Informative arts such as the work by PLAY [30] as well as InfoCanvas [22]. The idea is to provide awareness about important material through an artistic collage of the material on one or more surfaces. To support this we are taking advantage of the open hypermedia techniques for anchoring links in arbitrary Web pages. Here we let family members make selections on arbitrary Web pages including the home server, submitting the corresponding anchors to a collage service together with a PlaceRep with a 'Collage' PresStyle. The surface identified by the PlaceRep will then display the selected text and graphics corresponding to the anchor according to some

schema with an expression designed to fit the actual room and the inhabitant's preferred level of calmness.

The collage service is meant to maintain an ongoing awareness of the updated view of information identified by the submitted anchors, thus an active crawler is need to regularly collect information form servers, filtering the parts of the pages needed, making an artistic transformation before the representation is dispatched to the surfaces pointed out by the PlaceReps that were associated with the anchor when submitted to collage service.

The MediaGate, the MediaTable, the MediaTray and the MediaWall together presents a vision of a domestic hypermedia system, which takes into account the specific challenges of the household. The MediaGate address the challenge of lazy structuring, the MediaTable offers new structuring experiences, the MediaTray provide new ways of linking digital and physical materials, and the MediaWall takes advantage of the meaning and richness of the surfaces of the home.

6. RELATED WORK

This paper covers both an empirical study and the design of a concept for Domestic hypermedia.

Compared to the studies by Crabtree [5], we have covered a broader range of material and media than just the physical mail. We have identified a variety of hypermedia like structuring mechanism in the physical world, which can inspire and challenge the future of design of Domestic Hypermedia systems.

Compared to the Jigsaw domestic component system proposed by Humble et al [17], we have taken a material centered approach. We have focused on the organization of domestic material and on how we can provide a seamless folding between the physical and digital material spaces. In achieving that we introduce a novel combination of open hypermedia, spatial hypermedia, physical hypermedia, and context-awareness in the DoHM infrastructure. Where Humble et al. [17] focus on supporting transformations between digital and physical material, we focus on linking and integrating the physical and the digital. We do this in terms of the home environment per se by developing support for the DoHM system which directly addresses surfaces in the home and let users address arbitrary surfaces from every DoHM client running in the home. With respect to the physical material, we provide a physical hypermedia linking and integration using RFID tags.

In the paper [11], we discuss outdoor geo-spatial hypermedia, and we make a distinction between metaphorical and literal spatiality. In the DoHM system we place ourselves in between these distinctions. The PlaceReps are literal in the sense that they represent an actual physical place or surface in the home. But it is a deliberate choice not to have an exact 2D or 3D model of the house to deal with, since that is far too complex for an action putting a picture on a specific notice board. Thus we view PlaceReps slightly more metaphorical in the sense that we can deal with e.g. "entrance" and have that cover a list of physical locations in the home. This supports inhabitants in developing a set of PlaceReps that makes sense to them. In the architectural folding terminology, we support the inhabitants in tailoring their own folding of the digital environment into the set of installed digital surfaces in the physical environment.

Compared to the existing spatial hypermedia systems ([21], [23]), we have introduced abstract representations (PlaceReps) of physical surfaces and places. A PlaceRep is associated with the composite which holds the collection of material to be presented according to the default behavior (specified by PresStyles). Thus selected composites in the DoHM system are continually connected to physical place or surface

With respect to physical hypermedia [12] aspects, we have not made fundamentally new mechanisms, but we have made a slightly simpler mechanism, which works with standalone artifacts. Like the MediaTray, which can be dynamically registered and thus utilize nearby surfaces. We build on the HyCon context-aware hypermedia framework [2], thus we can support a rich variety of sensors beyond the RFID tag readers currently integrated in DoHM. Thus we may develop support for a richer set of context-based services.

7. CONCLUSIONS

In this paper we have presented an empirical study of the use of primarily physical material in private homes. We have illustrated how taking the context of the home seriously implies certain challenges for domestic hypermedia. Designing for the pragmatics of real domestic life, rather than for some kind of idealized visions of human activities and domestic environments implies for instance supporting lazy structuring of domestic materials. It implies using the rich set of surfaces of the home as a resource in design, and it implies challenging the setting of the personal computer and explores how collective and more playful structuring mechanisms can be developed. Based on the challenges revealed in these studies we have described the design of a new Domestic Hypermedia infrastructure called DoHM, which supports the folding of spatial and navigational hypermedia into the physical environment of a home. We have presented a couple of novel home appliances that take advantage of the DoHM infrastructure and fold the hyperspace into the living room. In the DoHM design we are assuming that future home appliances in general will be integrated in a TCP/IP network infrastructure with wired and wireless LAN and WebDAV based home servers. This assumption is grounded in the emergence of multiple Ethernet enabled HiFi and TV appliances for the home. We have established the basic DoHM infrastructure and are initiating the initial experiments with users introducing the appliances being designed.

We have developed the first lab prototypes of the appliances and the DoHM infrastructure, and they will be evaluated both in our lab and in specific home settings within the coming months.

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9. REFERENCES

[1] Amitech eHome www.amitech.dk

[2] Bouvin, N.O., Christensen, B.G., Grønbæk, K., Hansen, F.A. HyCon: A Framework for Context-aware Mobile Hypermedia. 2003. To appear in NRHM journal volume 9.

[3] Brand, S. (1994) How Buildings Learn. New York: Viking

[4] Büscher, M., Christensen, M., Grønbæk, K., Krogh, P., Mogensen, P., Shapiro D., & Ørbæk, P. Collaborative Augmented Reality Environments:Integrating VR, Working Materials, and Distributed Work Spaces. In proceedings of CVE2000, San Francisco, Sept. 10-12, 2000, pp. 47-56.

[5] Crabtree, A., Hemmings, T. and Rodden, T. (2002) "Coordinate displays in the home", CSCW Workshop on Public, Community and Situated Displays, Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work, New Orleans: ACM Press.

[6] Crabtree, A., Hemmings, T., and Rodden, T. (2002) Patternbased Support for Interactive Design in Domestic Settings. In Proc. of DIS2002, ACM Press, pp. 265-275.

[7] CSS. http://www.w3c.org/Style/CSS/

[8] Eggen, B., Rozendaal, M. and Schimmel, O. (2003). Home Radio - Extending the Home Experience beyond the Boundaries of the Physical House. In Proceedings of the Home Oriented Informatics and Telematics,University of California, Irvine, April 6-8, 2003.

[9] E-Ink. http://www.e-ink.com

[10] Grønbæk, K. & Trigg, R.H. From Web to Workplace: Designing Open Hypermedia Systems. MIT Press, Boston Massechussets. July 1999, 424 pp (ISBN 0-262-07191-6).

[11] Grønbæk, K., Vestergaard, P.P., & Ørbæk P. Towards Geo-Spatial Hypermedia: Concepts and Prototype Implementation. In proceedings of the 13th ACM Hypertext conference, June 11th - 15th, 2002, University of Maryland, USA, ACM, New York, 2002.

[12] Grønbæk, K., Ørbæk, P., Kristensen, J.F., and Eriksen, M.A. Physical Hypermedia: Augmenting Physical Material with Hypermedia Structures. To appear in New Review of Hypermedia and Multimedia (NRHM). Vol 9. 2003.

[13] Gyricon SmartPaper. http://www.gyricon.com

[14] Halasz, F. and Schwartz, M. (edited by Grønbæk, K. and Trigg, R.H.) The Dexter Hypertext Reference Model. Communications of the ACM 37, 2 (Feb. 1994), pp. 31-39.

[15] Holmquist, L. E., and Skog, T. (2003) Informative Art: Information Visualization in Everyday Environments. In Proc. of the first intl. conference in computer graphics and interaction techniques in Australia and Southeast Asia.

[16] Home Gateways. http://compnetworking.about.com/cs/homegateways/

[17] Humble, J., Hemmings, T., Crabtree, A., Koleva, B. and Rodden, T. (2003) "'Playing with your bits': user-composition of ubiquitous domestic environments", Proceedings of the 5th international Conference on Ubiquitous Computing, pp. 256-263, Seattle: Springer.

[18] KISS http://www.kiss-technology.com/

[19] Kjær, A., Madsen, K. H. & Petersen, M. G. (2000) Methodological Challenges. In The Study Of Technology Use At Home. In Home Informatics and Telematics: Information, Technology and Society, Sloane, A. and van Rijn, F. (Eds.) Boston: Klüwer Academic Publ., pp.45-60

[20] Lynn, G. (1994) Architectural curvilinearity : The Folded, the Pliant and the Supple. In Folding in Architecture. Architectural Design Magazine. Academy Grp Ltd., pp. 8-15.

[21] Marshall, C., & Shipman, F. Spatial hypertext and the practice of information triage, In Proc. Tenth ACM Conference on Hypertext (Hypertext '97). (Southampton, UK, Apr, 1997), pp. 124-133.

[22] Millar, T., Stasko, J. (2001) The InfoCanvas: Information Conveyance through Personalized, Expressive Art. In Proceedings of CHI 2001, ACM Press, pp. 305-306.

[23] Mogensen, P. & Grønbæk, K. Hypermedia in the Virtual Project Room - Toward Open 3D Spatial Hypermedia. In proceedings of ACM Hypertext 2000, May 30 - June 3, San Antonio, Texas, USA.

[24] Monk, A. (2000) User-Centred Design. The Home use challenge. In Sloane, A. & van Rijn, F. Home Informatics and Telematics. Information, Technology and Society. Kluwer Academic Publishers, pp. 181-190.

[25] O'Brien, J., Rodden, T., Rouncefield, M., and Hughes, J. (1999) At Home with the Technology: An Ethnographic Study of a Set-Top-Box Trial. In ACM Transactions on Computer-Human Interaction, Vol. 6, No. 3, pp. 282-308.

[26] Pallasmaa, J. (1994) Identity, Intimacy and Domicile. Notes on the phenomenology of home. In Finnish Architectural Review 1 / 1994.

[27] Petersen, M. G., Madsen, K. H. and Kjær, A. (2002) Usability of Everyday Technology – Emerging and Fading opportunities. In ACM Transactions on Computer-Human Interaction, Vol. 9, No. 2, June 2002, pp. 74-105.

[28] Petersen, M. G. and Baillie, L. (2001) Methodologies for Designing Future Household Technologies. In Proceedings of the OIKOS2001 Workshop, Aarhus University Press, pp. 47-49

[29] Premkumar, G. P. (2003) Alternate distribution strategies for digital music. In Communications of the ACM, September, Volume 46, Issue 9.

[30] Redström J, Skog T & Hallnäs L. Informative Art: Using Amplified Artworks as Information Displays. In Proceedings of DARE 2000, Designing Augmented Reality Environments, ACM, 2000, Elsinore, Denmark

[31] Silverstone, R., Hisch, E. & Morley, D. (1992) Information and communication technologies and the moral economy of the household. In Consuming Technologies. Media and Information in Domestic Spaces. Routledge. London and New York. pp. 15-31.

[32] Tolmie, P., Pycock, Diggins, T., MacLean, A., and Karsenty, A. (2001) Unremarkable Computing. In Proceedings of CHI2002, ACM Press, pp. 399-406.

[33] Weiser, M. & Brown, J.S. (July 1996) "Designing Calm Technology", PowerGrid Journal, v 1.01.

[34] Wisneski, C., Ishii, H., Bahley, A., Gorbet, M., Braver, S., Ullmer, B., & Yarin, P.: Ambient Displays: Turning Architectural Space into an Interface between People and Digital Information: Cooperative Buildings. Springer Verlag, February 25-26, 1998.