Design Patterns for Private and Public Digital Spaces in the Home Environment

(Abbreviated Title: Private and Public Digital Spaces)

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SUMMARY

With the introduction of information and communication technologies into our homes and the different physical and communicative expressions this implies for our living spaces the concept of being *private* and being *public* becomes crucial. In this paper we introduce the so called *design patterns,* developed by Christopher Alexander in the 1970s, in order to handle these problems systematically. The presentation formally follows Alexander's structure in some cases, which are all related to practical experiments on being private or public at home. We start with a number of concrete user situations related to human-computer interaction. Social and communicative phenomena or possibilities end up in novel design patterns at the interface between an architectural and a technological perspective.

The novel patterns presented are primarily based on experiences from practical work on the development of a conceptual dwelling of the future, *comHOME*, designed and constructed as a full-scale model of a flat. By creating different zones for video-mediated communication, *comZONES*, the user can control the private and public digital areas varying in time and

space. The novel patterns refer to two separate levels. One pattern, called "PRIVATE AND PUBLIC DIGITAL SPACES", is designed as a conceptual floor plan layout that distributes private and public digital spaces for video-mediated communication over the flat. At a secondary level, four patterns show the integration of the specific comZONES aiming at solving four specific problems with video-mediated communication at home.

The intention is to describe the application of design patterns as a method also for analysing and solving novel problems encountered with the introduction of information and communication technologies more generally in our homes. The video-mediated set-ups are not dealt with in depth as these are designs that makes it possible to apply the design patterns. In this way we pursue one of the methods available for the sciences of the artificial.

Keywords: *architecture, communication, comZONE, design, dwelling, home, ICT, intelligent building, media space, patterns, pattern language, private, public, sciences of the artficial, smart home, space, video-mediated communication, VMC, zone*

1 BACKGROUND

We are now experiencing a transition from the industrial society to the society of information, or to any other notion that can be used to describe the profound change now taking place. The information and communication technologies (ICT) are the prerequisites for the current transformation process from a society based on the production of goods to a society characterised by information processing and communication (Dahlbom, 1997). One emerging consequence regards the way we will use our homes in the future. Increasing interdependence in both time and space between work, shopping and traditional domestic activities is assumed to take place. Further, ICT are assumed to support novel and changed processes in the home, thereby overcoming the traditional organisation of these domestic activities. Many of these processes have a public or semi-public aspect, especially those supported by video-mediated communication (VMC). But to a large extent the existing building stock seems to lack the qualities needed to support those processes. The earlier "public" character of a traditional farmer's house or bourgeois flat (in Sweden) has disappeared with the modern housing planning. Instead, distinguishing the public from the private has become central during the industrial age, with the dwelling as an exclusively private place. Now, with the transition to an information society, it seems as if the concept of public space in the private dwelling has to be reconsidered (Junestrand & Tollmar 1998), which also means that the borders between the private and the public at home have to be opened up (Graham & Marvin 1996).

A slight orientation towards the future is a prerequisite for the discussion in this paper for three main reasons: First, the processes of everyday activities in the domestic environment and their organisation in time and space will change due to the development of technology. Second, the fast development of technology itself will most probably result in more affordable devices. Third, an increased bandwidth in homes will enable enhanced communicative services.

1.1 Video-Mediated Communication in the Domestic Environment

Trends and tendencies indicate that video-mediated communication, VMC, will become an important communication channel to and from our homes (Kraut and Fish, 1997). The VMC communication can, in this context, support and complement a wide range of home based

activities like professional work, studies, care of elderly and disabled persons, leisure activities and consultations with a bank or a doctor etc. (Junestrand & Tollmar, 1999). For a number of reasons, dwellings, at least in the western world, are generally not very well suited for VMC, because of, for instance, unsatisfactory acoustics, light conditions, technical installations, floor-plan layout and spatial design. Also, substantial difficulties have been encountered in the establishment of a market for video-conferencing in the professional field. Furthermore, VMC, with its current solutions for traditional offices, does not seem to be perfectly suited for homes. In spite of these facts we believe that VMC is a future technology for the home, mainly because of the fact that VMC primarily supports social and emotional aspects of communication, which are a primary requirement for a VMC system at home (Kraut and Fish, 1997 and Whittaker, 1995).

It is worth mentioning that most currently available VMC solutions lack significant qualities such as the capacity of transferring information with regard to gaze awareness (eye-to-eye), smell, taste and touch, and many other physical cues that people use to communicate in real life. Although it is an interesting topic of its own, it is too far-reaching for the scope of this article.

1.2 The Home of the Future - a Multidisciplinary Design Problem

The design of the built environment of the future is multidisciplinary and it requires mixed competencies, i.e. architects, mechanical engineers, electrical / lighting engineers, telecommunication designers and construction managers (Hartkopf et al, 1999). With the introduction of new “smart” technologies in our homes it has been also identified a growing need also for human-computer interaction specialists to get involved in the design process (Hughes et al 1997). One emerging problem in the design process of residential houses is the increased importance of competence in the ICT field of knowledge and the speed of development in this field. Another problem is that the change of home based activities and their organisation in time and space is not fully understood by those involved in the design process. The expertise involved, including the architects, seems to adapt to standard solutions without the necessary concern for the new requirements. In this context, Pemberton and Griffiths (1998) write: "Clearly it would make sense if, rather than each profession conceptualising the problem and the solution in its own way, they shared some terms and mental structures for communication and design goals and constrains which apply in each

area. Buildings need to be designed by people capable of speaking a common language". In fact, such a language was introduced by Christopher Alexander in the 1970s and was then called *A Pattern Language*.

Pemberton and Griffiths (1998) argue that the various generally available design processes can be effectively applied also to architectural and building engineering design from the 1960s and onwards in the US and Europe. In particular, in the complex multidisciplinary domain of co-operative building design, they see a place for the Design Patterns methodology. Although Alexander's design patterns were originally developed for the domains of architecture, town planning and interior design, they have been applied very intensively and successfully over the last few years in the area of computer science, e.g. in object-oriented design. The approach of using Design Patterns as a method for solving multi-disciplinary design problem has encouraged us to develop a number of new patterns for the design of the future home environment and technologies, primarily as an experiment on the applicability of the Design Pattern methodology to novel problems of the kind mentioned. This will probably play an increasing role in interactions design as well as software design.

2 A PATTERN LANGUAGE AS A DESIGN METHODOLOGY

The work of Christopher Alexander during the 1970s on the development of a *pattern language*, PL, emerged from a desire to explore the unmeasurable aspects of architecture, which he considered had largely disappeared in the modern planning and building during the 1950s and 1960s. The work resulted in several volumes. *The Timeless Way of Building* (Alexander, 1979) contains a basic description of the making of towns and buildings. In this book, Alexander intends to show that towns and buildings will not come alive unless all people in society make them alive by means of a common PL. The book can be described as a theory of PL. In spite of some political undertones, his work provides a valuable theoretical framework that is necessary for the understanding of the concept of PL.

In the second book, *A Pattern Language* (Alexander et al., 1977), an applicable PL is presented. The PL has the structure of a network. "The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our built environment, and then describes a core solution to that problem, in such a way that you can use this solution a million times over, and without ever doing the same way twice."

(Alexander et al., 1977). A core solution, a notion used by Alexander, is the equivalent to a generic solution in terms of systems theory.

"The patterns are ordered, beginning with the very largest, for regions and towns, then working through neighbourhoods, clusters of buildings, buildings, rooms and alcoves, ending finally with details and constructions. This order, which is presented as a straight linear sequence, is essential for the way the language works" (Alexander et al. 1977). Most important is the hierarchical connectivity between the patterns on different levels. This connectivity relates all patterns in a sequence to each other, like a semantic tree representing a total structure.

The patterns of Alexander have the following format and structure (Alexander et al., 1977 and Pemberton & Griffiths, 1998):

Concept	**Form**	**Description**
Title	Pattern no. & Text & 0-2 stars.	Indicates the design solution of the pattern. The stars indicate the validity of the pattern, two at most.
Picture	Photo or illustration	An archetypal example of the pattern.
Introduction	...Text	The context for the pattern by means of links to larger patterns. Starts with three dots.
Diamonds	◊ ◊ ◊	Three diamonds mark the beginning of the problem
Headline	Text in bold type	The essence of the problem in one or two sentences.
Body of problem	Text and illustrations	The empirical background to the pattern, the evidence for its validity, the range of manifestation in a building and so on.
Solution	Text in bold type	The field of physical and social relationships which are required to solve the stated problem in the stated context. The solution is always stated in the form of an instruction so that you know exactly what you need to do to build the pattern.

Diagram	Drawing and text	The solution, in the form of a diagram, with labels that indicate its main components.
Diamonds	◊ ◊ ◊	Three diamonds to show that the main body of the pattern is finished.
Connections	Text...	Tie the pattern to all the smaller patterns that are needed to complete this pattern. Ends with three dots.

Figure 1. Scheme of Pattern Design

Alexander writes (Alexander, 1977) that "the patterns are very much alive and envolving. In fact, if you like, each pattern may be looked upon as a hypothesis like one of the hypotheses of science. In this sense, each pattern represents our current best guess as to what arrangement of the physical environment will work to solve the problem presented. The empirical questions centre around the problem - does it occur and is it felt in the way we describe it? - and the solution - does the arrangement we proposed in fact resolve the problem? And the asterisk represents our degree of faith in these hypotheses. But no matter what the asterisks say, the patterns are still hypotheses, all 253 of them - and are therefore all tentative, all free to envolve under the impact of new experience and observation." This quote rather well explains our own approach to the use of patterns.

We are not unaware of the weaknesses of the PL, e.g. its top-down problem solving principle, which not always corresponds to a real design process. Anyhow, we have found it reasonable to make an attempt to use PL as a design method for the home environment in connection with new communication media to the homes, especially VMC. The patterns introduced by us are presented with the strict use of Alexander's structure described above (see fig. 1). In the long term it may fail, but in the short term, at least, it offers a scheme that demonstrates and communicates the ideas and experiences we have acquired.

3 SOME THEORETICAL CONSIDERATIONS

The multi-disciplinary work on developing the design patterns presented in this article covers a number of specific fields of knowledge that represent our principal perspectives: the architectural, the technological and the social. Each of these fields has its own theoretical framework. These frameworks are represented below by the most interesting, inspiring and relevant research going on. Although our research touches upon a number of diverse disciplines, all research activities refer to the theory of design. One basic source is the "Sciences of the Artificial" introduced by Herbert Simon in the 1960s (Simon, 1981) and further developed by Bo Dahlbom in the 1990s (Dahlboom 1997). Therefore, the PL should be seen as a design method rather than as a theory.

3.1 Design theory

According to Simon (1981), the design process, contrary to the natural sciences, aims to define how things *ought to be*, rather than tell us how things *are*. This leads to Simon's four criteria for the sciences of the artificial:

- Artificial things are synthesised by man (like our homes, communication systems and devices).
- Artificial things may imitate the appearance of natural things, but lack in one or several respects the reality of the latter (an image of a man on a screen is not the man himself, although we may neglect this fact under some circumstances).
- Artificial things can be characterised in terms of functions, goals and adaptation (e.g. a VMC communication shall convey messages, intentions and emotions more fully than a telephone communication).
- Artificial things are discussed, particularly when they are being designed, in terms of imperatives (shall, ought to) as well as descriptives (is, will become).

Dahlbom criticises Simon, not for the approach, which he fully endorses, but for not bravely fulfilling the path he has initiated. Dahlbom stresses the fact that we live in a world of artefacts that both enable us in different respects and influence our lives. The research on artefacts is oriented towards the future, in the spirit of Simon (1981) "How things ought to be". The research methodology, Dahlboom argues, very much resembles *an archaeology of*

the future. While the ordinary archaeologist creates a picture of the past by searching for fragments from earlier cultures and synthesising and interpolating these fragments to larger structures and contexts, the scientist of the artificial makes small or large designs (fragments of the future), with the intention to model and simulate possible larger portions of the future.

Dahlbom (1997) writes: "When we realise that the world we live in is an artificial world, a world of human creation, made up of artefacts of all kinds, becoming even more complex and intertwined, our attention will shift from studying nature to contributing to the design of artefacts. In this future science we become, as designers, a part of the design". In this way, the intention with our research is to investigate what is possible in the design and thereafter structure, analyse and communicate our findings.

3.2 Social aspects of everyday technology in the home

In predictions about future societies, the different domains of work and play, education and entertainment, industry and the arts, and of the public and private sectors, are no longer strictly separated, neither at home nor at work. Transactions and communications continue around the world at the same pace, day and night, whether we are awake or asleep. At home, too, many activities are performed simultaneously; cooking while watching TV, monitoring the children sleeping in the bedroom while entertaining friends in the living room; working while listening to music (Venkatesh 1997).

Hughes et al (1997) describe the role of technology in the home environment mainly from a sociological viewpoint. The authors argue that the influence of using new technology in home environments is increasing. They found that the presence of technology within the home is absorbed so completely into the routines of home-life that it becomes yet another way in which these routines can be articulated. However, technology is not applied without problems in daily life. On the contrary, the context of home activities is generally strict. The activities are often constrained by negotiated as well as by unspoken rules. If reconfigurations of rooms occur often, they are carried out within given boundaries. The authors also found, in cases where technology was the reason for the rearrangement, that this fact caused considerable stress. The technology was then perceived as being badly designed and not user-friendly.

3.3 Architectural design

The architectural design issues are related to the explorative and creative development of the early functional period of international architecture. Primarily, this design refers to the development of novel conceptual and practical ideas for the dwelling that took place at the beginning of this century. The building was referred to "as a machine to live in" (Le Corbusier, 1923) and not to the traditional central place in peoples' emotional and social lives. There is also a direct reference to the more formal aspects of architectural design as far as cognitive and psychological aspects are concerned (cf. Hall, 1966 and Weber, 1995).

Architectural projects and research related to the use of information technology in the home environment, intelligent buildings or smart homes, appear to be focused on the technology rather than on the spatial design. An exception is the work by Olindo Caso (Caso & Tacken 1993) , which concerns the analysis and classification of different IT-supported activities that can be carried out in the home environment. The study includes no experimental verifications but gives a comprehensive overview of some of the principal questions discussed here.

3.4 Computer Supported Cooperative Work (CSCW)

Within the research area of CSCW, the importance of a medium that could support informal communication has been discussed for a long period of time (Kraut & Fish, 1997). The presence or absence of a social context deeply influences the progress and results of conversations. Kraut et al. (1990) states that informal communication is an essential form of human communication. Studies of video-communication have indicated that the predominant contribution of the video-medium is the rich social context (Tang & Isaak, 1993). It is also assumed that informal network building and maintenance will become even more crucial for the individual when an increasing part of the professional work will be carried out at home, in comparison to that in ordinary work organisations. Consequently, we assume, with some degree of confidence, that VMC has the potential to become one of the major communication media for work at home.

Naturally, as VMC moves from the office environment to the domestic environment, we should be able to learn many important lessons from the CSCW research. In the context of video communication for remote collaboration, the major focus has been on whether the video

medium actually improves conversation or not. A great deal of work in this field has moved along the path of finding and separating variables that could be used in studies in order to solve the question of how valuable the video medium exactly is. In some cases, researchers have been able to separate variables moving along deterministic paths. However, it has turned out to be difficult to generalise these findings (Whittaker, 1995). In more current research on mediaspace, non-quantitative studies were conducted in an attempt to specify users' perception and awareness of the presence of others. Furthermore, mediaspaces appear to be especially well suited for informal communication (Bly, 1993 and Dourish, 1995).

4 COMHOME - A VISION OF A FLAT OF THE FUTURE

Our primary research site is the *comHOME* flat, which simulates a dwelling of the future. The site is used both as a laboratory and as a showroom. The comHOME project covers several aspects of a future dwelling. Our primary goal in the comHOME project has been to develop and integrate VMC solutions into a home, although we are also working on making the home smart. *Smart* in this context refers to an object or an environment that contains one or more of the following characteristics. It is:

- *interactive*, i.e. the user can interact with the device and influence the way it is working;
- provided with *information and communication technology*, e.g. sensors, processors, and software;
- *communicable*, which means that messages between the user and the device/system can be conveyed and exchanged;
- set-up with *novel types of interfaces* such as speech, gestures, positioning and touch that differ from traditional ones (screens, keyboards and mice);
- *adaptive* to individual needs and desires;
- *learning*, i.e. it automatically learns and supports the user's habits.

The authors of this article bear the primary responsibility for the architectural and technological design of the comHOME dwelling. However, the project was conducted in co-operation with a telecom operator and a company providing and developing Lon-Works automation technology.

It should be emphasised that the comHOME flat by no means is a complete dwelling. For example, there is no bathroom, and the general floor-plan layout is not intended for living in. The flat could be described as a full-scale model that is constructed out of a number of set-ups, each based on a scenario. Each set-up is independent. The flat forms the physical framework supporting these set-ups, and at the same time it very much resembles a small flat with two rooms and a kitchen. For example, a general activity called "telework" in the home environment should not be confined to a specific area, such as the "home-office", as in the comHOME flat. Rather, the whole dwelling with its variety of spatial and social qualities should be seen as a potential place for "telework" (Junestrand & Leal, 1998). Nor is it intended that anyone should actually live in this flat for any extended period of time for any other reason than purely experimental.

The comHOME dwelling consists of three rooms: a living room, a kitchen and a combined home office and bedroom. In our attempt to explore the usability of the concepts *private and public digital spaces,* we have designed a set of four places, *comZONES*, for which we have created different architectural and technical design set-ups. Each comZONE has been developed to support one or several home based activities. Metaphors have been used and developed to get a focus on and a common vision of the different VMC-systems (the metaphors are presented in brackets below):

- A **videoTORSO** for informal everyday communication, equipped with a large vertically mounted flat screen, for people standing and talking, is placed in the kitchen ("a person in the doorway").
- A **comTABLE,** located in the kitchen, contains a computer and a screen and enables a virtual dining guest to take part in a dinner or a cup of coffee ("a guest for dinner").
- A **workPLACE** for professional work in the home environment is located in the combined home office and bedroom ("the table at the office").
- A **mediaSPACE**, an extension of the physical room, provides a larger social space with the digital representation of another space ("a shared living room").

The comHOME flat was primarily built on the basis of existing "on the shelf" technologies. The presentation of the new design patterns below describes a mix of what has been done and visions of what is going to be done in the near future in the design of the comHOME flat. The

solutions of the different comZONES will not be further described here (for more detailed descriptions of the comHOME flat and related issues, see Junestrand et al. 2000 and Junestrand & Tollmar 1999). Furthermore, as will described in the end of this text, has a couple of different evaluations of, e.g., interaction and usability aspects been studied.

5 RESEARCH QUESTIONS AND CONSTRAINTS

The research project aims to 1) explore and 2) make proposals for new patterns when using ICT in the home. Relevant future research topics are to be developed as well. The general research objective is the following:

- How should VMC solutions be designed and integrated into a future home environment, considering the need for both private and public spaces in the home?

From this starting point, more specific research objectives can be formulated. As mentioned earlier, the questions can be referred to two levels. The first level regards the whole floor plan layout of the dwelling:

- What should a general floor plan pattern look like in a home of the future, considering the integration of digital public and private space?

The second level addresses the specific VMC solutions proposed or designed:

- How should the different design patterns be formulated in order to generalise the experiences of the specific comZONES, set-ups, developed for the comHOME?

General background questions could further guide the work:

- What processes of future everyday activities in the home environment can and should be supported by VMC?
- How should the specific VMC set-ups be designed for the activities they are supposed to support?
- What does the organisation of time and space for everyday activities look like in a future home environment?

- How can VMC be integrated with other advanced domestic technologies and a general smart system?
- How can the design pattern methodology contribute to the formulation of requirements for the interfaces, in order to facilitate user interaction with the VMC system?

Below, we will elaborate some of these questions further, by applying the pattern language methodology according to Alexander, as described earlier. In a way, this is an intellectual exercise, in order to explore the applicability and range of the principle of PL. Our aim is to contribute to better insight into the crucial issue of public and private spaces, and into the VMC and its constraints, by applying the PL.

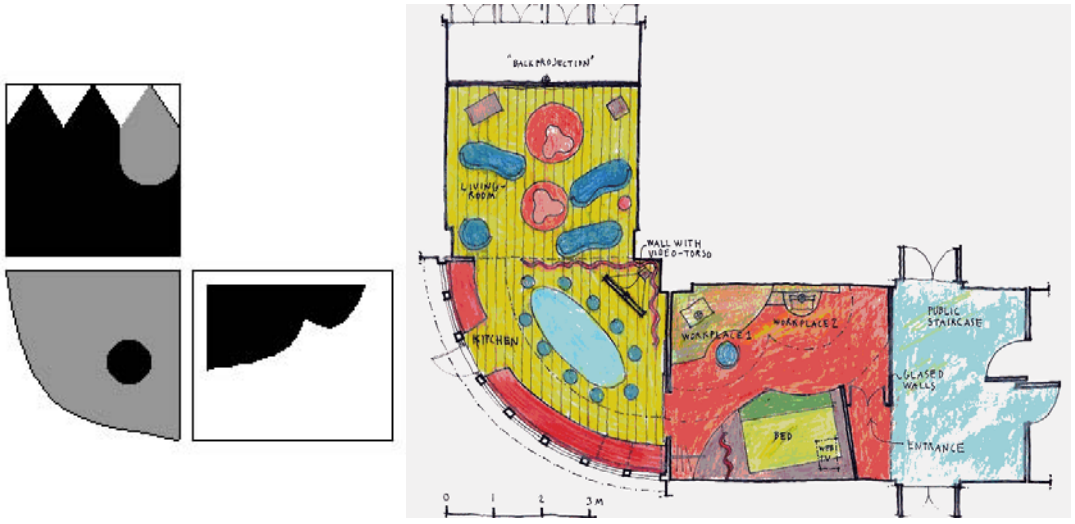
As pointed out above, many restrictions have to be considered when the results from the analysis are interpreted. Communication of other sensations than image and sound, such as tactile communication, smell and taste, are not supposed to take place, although such qualities will not be excluded definitely in the long term. We are also limiting ourselves to images on screens and, in one case, back projection. Furthermore, several activities could certainly have locations that are better suited for a part of the dwelling process than those arranged for and described here. Reading a book in a sofa, for instance, is more natural than in front of a display for the telework case. However, this is no real limitation for the work discussed here. The core activities carried out at the *digital workPLACE*, for instance, are to be examined and described with the help of the Pattern Language. The work described here is a test of the Pattern Language as a design and communication method, rather than a test of specific set-ups. Finally, to date, only fixed place activities have been set up.

6 DESIGN PATTERNS FOR PRIVATE AND PUBLIC DIGITAL SPACES IN THE HOME ENVIRONMENT

A set of new patterns developed from the comHOME flat is presented in this section. The patterns strictly follow the structure of the original pattern language presented by Alexander (1977). The number given to each new pattern is chosen so that we, in the best possible way, can introduce our new patterns in the context of an existing pattern language, the one of Alexander (1977). From the perspective of the design of a home, the patterns represent two structural levels, as mentioned above. First, there is a general pattern "PRIVATE AND PUBLIC DIGITAL SPACES" for a flat, which is shaped as a grid over a conceptual flat floor

plan and distributes private and public (fixed and flexible) spaces for Video Mediated Communication (VMC). Second, at a level below the general one, there is a number of patterns that provide solutions for the integration of different comZONES (communicative zones for VMC) that support different home activities, where the resident can be seen and heard at different levels varying in time and space. The comZONES presented include a “videoTORSO” - a place for informal everyday communication; a "workPLACE" - a set-up for professional work, surrounded by a private sphere; a "comTABLE" - a dinner table with an integrated screen for the representation of a remote guest; and a “mediaSPACE” - a social space consisting of a wall of screens permitting shared activities in both time and space. The comZONES are described principally from an architectural perspective (representing form and function) and a technological perspective (hardware and software). Note that the descriptions of the comZONES in the proposed patterns are a mix of existing technologies on the one hand, and design concepts and goals that are not yet fully in use, on the other.

6.1 *(127 b) PRIVATE AND PUBLIC DIGITAL SPACES*



The current development of information technologies is rapid and VMC will most probably become an important part of the communication to and from our homes in the future. VMC has partly a public and partly a private character. This pattern helps to distribute private and public digital spaces when the dwelling is being designed. It is also connected to THE

FAMILY (75), the HOUSE FOR A SMALL FAMILY (76) and the HOUSE FOR A COUPLE (77). It also refers to the MAIN ENTRANCE (110) and complements (and in some way opposes) the INTIMACY GRADIENT (127).

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New public digital spaces are created when activities supported by video mediated communication are performed throughout the domestic environment. This breaks the earlier hierarchical separation of private and public spaces in the design of the home. If the different aspects of this problem are not addressed consciously many people will feel uncomfortable and insecure in their own homes.

In our empirical work, we designed comHOME - a dwelling of the future. The spatial design of comHOME supports activities with the use of VMC and is based on the idea of creating different comZONES (zones for video mediated communication) in order to support the demands of both private and public digital spaces in the home. In *public zones*, a person can be both seen and heard with the help of an image and a sound recorder (VMC). In *semi-public zones*, the individual can be seen but not heard. In the *private zones*, the resident can neither be seen nor heard. The zones are variable in time and space.

The governing architectural principle in the design of the comHOME flat was to establish the mental and physical boundaries between the public and the private zones. Not to be seen nor heard when demanded was a principal requirement. A good balance between the VMC-activities and other everyday activities is important. Both the inside-out and the outside-in perspectives are acknowledged, i.e. how the outside is perceived through VMC from the inside, and how the inside is perceived from the outside. This was solved by the creation of a number of comZONES intended to support a number of everyday activities. The different comZONES are expressed by technical set-ups - screens and cameras - and by using architectural terms - spatial forms, colours, light, materials. Thus, the architectural space related to ICT solutions forms an interface to the digital world (see the following patterns for descriptions of each of the comZONES).

Developing VMC in the comHOME setting uncovered multiple layers of complexity. First, a home is a radically different place compared to the more controlled office environment, and poor lighting and audio conditions, for instance, should be considered to be the norm rather

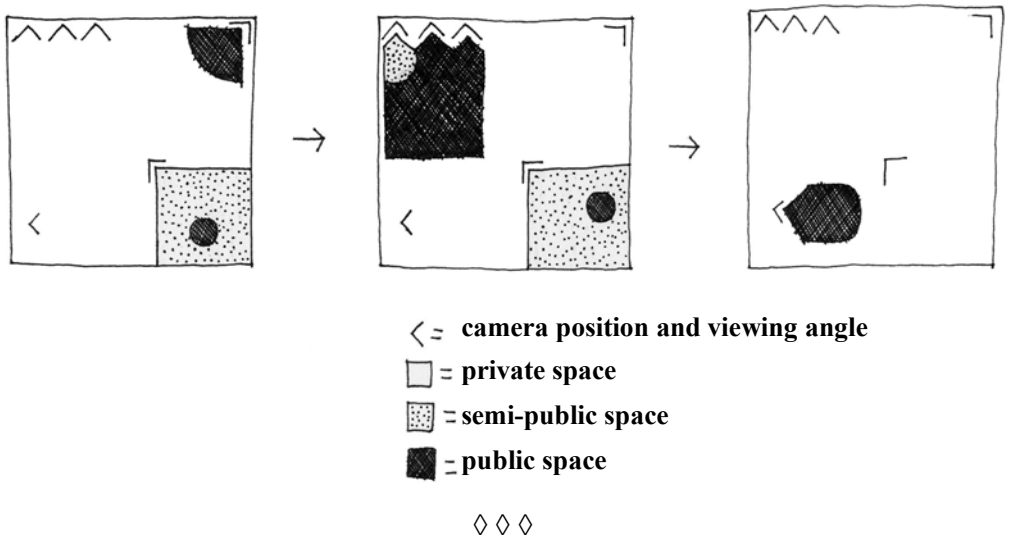
than the exception. The technical design of the video and audio space in comHOME is based on several short-range cameras and microphones that are mapped and routed through a common media switch. The switch could be seen as the heart of all incoming and outgoing media streams. The control of the media switch is monitored either via a remote control or via a graphics user interface, or, automatically, by the central logic of the smart home. Further, a default set-up could be activated by the central logic of the smart home that governs the data stream through the media switch. Hence, the video and audio space is closely linked to the automation of comHOME as a smart home. An incoming video call, for instance, could automatically be routed to the room where the receiver is and trigger dimming of the lights and muting of the radio in the room.

The different comZONES for the rooms in comHOME can be created in many different ways. Reducing the number of potential solutions is a major undertaking. With the location of the cameras, the control of depth of field, and viewing angles, the video space in the different zones could be adjusted quite well. The control of the audio space is more crucial. Array microphones and spatially directed loudspeakers might be a solution. However, experience of these technologies was lacking. Similarly, real time image manipulation, which extracts irrelevant background activities, can be used in some cases. Early works have proposed the use of physical metaphors for the control of the video and audio space in VMC systems. One approach, suggested by Kawai (1996), was to use a graphics user interface with a floor plan in order to control the viewing range of the cameras. Most of these methods suggest an explicit and direct control of the cameras. For comHOME, the variation of the zones in space will mainly be controlled by a spatial recognition system linking the physical position to the identity of the person(s) in the room.

Therefore:

Design and locate the comZONES in the dwelling in such a way that they support the specific activities they are designed for in the best way possible. At the same time the design and location of the comZONES have to be integrated in such a way that they do not interfere with other everyday activities. The comZONES should be expressed both in the architecture and technology and made to fit naturally into the home environment. The public places may vary in time and space but it should always be clearly indicated whether the comZONEs are in a communicative mode or not, i.e. if the space is *public* at

the moment. This should be done by a clear feedback to the user (similar to WYSIWYG - what you see [and hear] is what you get, but with an extended and entirely new interpretation). This will make people feel comfortable and secure in the home environment.



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Consider the possibility to use INDOOR SUNLIGHT (128) for some comZONES and create comZONES in relation to COMMON AREAS AT THE HEART (129). To complete the pattern, consider A ROOM OF ONE'S OWN (141), a good distribution of SEQUENCE OF SITTING SPACES (142) and that the STRUCTURE FOLLOWS SOCIAL SPACES (205).

(196b) videoTORSO

A desire for more informal social contacts with remote friends and members of the family can be fulfilled with the help of a videoTORSO, which is a set-up enabling communication with a person as if he/she was standing at the doorway. This pattern helps to complete the aspect of informal social communication in PRIVATE AND PUBLIC SPACES (127 b), COMMON AREAS AT THE HEART (129) and at the FARMHOUSE KITCHEN (139), and makes the design applicable to the home context.

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Family members and friends seem to have less and less time to spend with each other. The lack of communication tears the family and relations apart.

Informal social communication between family members and friends is crucial to the establishment and maintenance of personal relations. But individuals, both within the family and among friends, seem to spend less time in each other's company. This concerns both the number of times people meet and the length of time they spend together. The physical distances between related persons also increase because of the fact that people travel more and longer distances and that the patterns of human habitat are more widely spread around the

world, for both social and economic reasons. The need for informal social communication in the domestic environment among family members and friends will probably remain strong. The *videoTORSO*, which is a VMC set-up, is intended to support this type of casual conversation style. The hardware and software of the videoTORSO consist of:

- A large flat screen placed on a wall, which is possible to adjust in height, thereby allowing for both tall and short standing users.
- Loudspeakers just above each side of the screen, making the sound appear from the videoTORSO.
- A camera with automatic tracking, placed as close as possible beside the eye level of the person appearing on the screen.
- Microphones, placed just beside the screen.
- Software for video communication, voice and gesture commands.

These parts are integrated in one single device, the videoTORSO, which makes it possible to convey social and emotional qualities similar to those that could be attributed to a person standing in the doorway of the room. The videoTORSO is connected to the central logic of the smart home, and enables routing of calls, positioning of people etc.

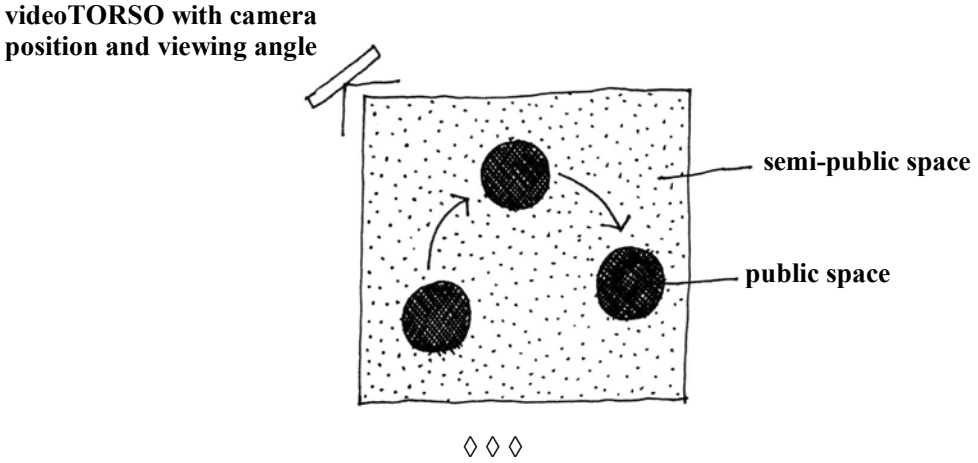
The location of the videoTORSO in the room is also essential. If the objective is to simulate a person standing in the room, it is important to locate it at a place which is comfortable and natural to turn to. It is also important to consider the tracking cameras connected to the videoTORSO. They capture the person and his background. The limits of the camera view (angles of tracking) have to be controlled. This can be done with architectural delimitations or software/hardware solutions and may restrict the location of the videoTORSO to places where the viewing angles and the background are physically obscured by the architectural design, e.g. a wall or a curtain. The sound in the room should be captured mainly from the person having the conversation. If several persons are participating, the sound from all of them should be captured. People in the room who are not participating in the conversation should only appear as images producing background sound and images and are thus *semi-public*.

The videoTORSO might well substitute a person in the room. The person at the other side of the screen, however, will not experience him/self being in the kitchen. Since the camera

automatically tracks the person in the kitchen, the environment is not fully perceived. This fact makes the dynamic space around and behind the communicating person a *public space* and the rest of the room becomes at least partly *semi-public* or *private*. It is fundamental that the system's feedback is clearly expressed. When testing the systems, we noticed that people feel that they themselves are not seen nor heard as soon as the VMC set-up is black and mute. It is recommended to locate the videoTORSO in an already relatively public space, preferably the kitchen, in the home where informal everyday activities take place. This provides high accessibility and natural user situations.

Therefore:

Create a videoTORSO, equipped with a large flat screen mounted on a wall, loudspeakers and a camera with tracking functions and microphones, constituting one single entity. Place it in a corner of the room, with the viewing space expressed in the spatial design. The public space should follow the user in the room. The rest of the room has to be considered as semi-public. Locate, if possible, the videoTORSO in the kitchen or another room that is often used for informal everyday communication. This system should be connected to the central logic of the smart home and be provided with an overall design that enables seamless communication of a high quality.



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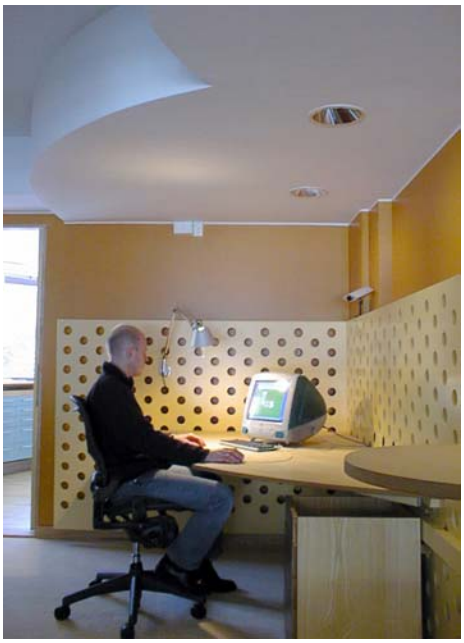
The FLOOR AND CEILING LAYOUT (210) and NATURAL DOORS AND WINDOWS (221) are crucial to the successful use of the videoTORSO. The design of this pattern is completed and might be improved by considering DEEP REVEALS (223) and the LOW SILL (222).

6.2 (157b) digital workPLACE



A workplace for professional work, as a part of OFFICE CONNECTIONS (82), supported by video-mediated communication in domestic environments, must often be perceived from the outside (by the remote person) as a *public* place. Sometimes, the space that this pattern forms is to be considered as A ROOM OF ONE'S OWN (141), although it should rather be considered as a space than as a room. It is also necessary to make the people in and around the digital workPLACE feel comfortable and *private,* so consider INTIMACY GRADIENT (127), PRIVATE AND PUBLIC SPACES (127 b) and THE FLOW THROUGH ROOMS (131). In some respects, this pattern replaces the HOME WORKSHOP (157), but in other respects it is a complement. If this pattern is used correctly it will be found that the integration of a *public* space into a *private* room works well.

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The use of VMC for professional work activities in a home environment could cause many problems, both for the person performing professional work supported by the video-conference and the persons around and behind the workplace, whose integrity can be disturbed and who may feel very uncomfortable. Therefore, it is also important that

one is able to feel private and comfortable when being or passing behind someone using a VMC set-up for professional work.

Professional work supported by ICT at home tends to increase. The working hours seem to be extended around the clock. The globalisation and increasing flexibility of working hours are the main reasons for this development. People tend to locate places for telework to very private spaces such as bedrooms, because of a lack of other suitable places at home. This might work well until VMC becomes a more common device for the work. Then it will be necessary to control the areas of the private space around and behind the workplace that can be seen by a videocamera at the desktop. But it will be equally important to be able to feel private and assured when being or passing behind someone using a VMC set-up for professional work.

In a set-up developed at the comHOME project, the workPLACE is placed in a combined home-office and bedroom, which causes the camera to view not only the person at work, but the bed behind, as well. This pushes the aspects of private and public to its limits and requires the development of architectural measures that facilitate the interpretation of the borders between *private* and *public spaces*, as well as complementary ICT devices and software. A table with two sideboards and a lowered ceiling with integrated light spatially defines the *public zone*, where the user can be seen and heard. The zone outside, with the bed, is *private*. This is achieved with a short-range microphone that captures only the voice from the person seated at the workPLACE, and with a software for the digital camera that cuts out the person sitting at the workPLACE and places her in the background of an office environment.

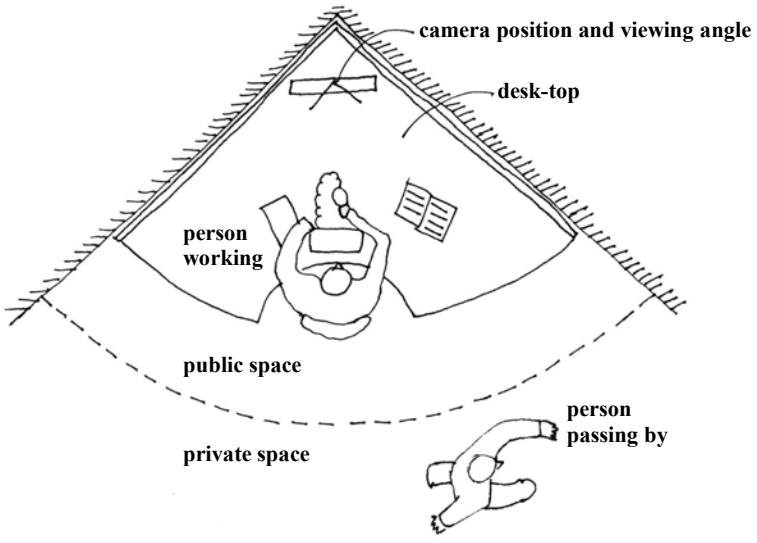
Upper left and right: the user appears as in the real home environment using the video-conference system. Lower image: from the remote place (the partner in the conversation) the user appears to be in an office environment.

The workPLACE only allows for the core activities supported by the VMC and the additional necessary equipment. (Other functions can be distributed arbitrarily throughout the dwelling). The space has one of several computer screens, with an additional desktop camera as the visual focus of the VMC. The workplace should include a comfortable table area that provides good ergonomic conditions. Besides, the workplace should be extended so that the desk top worker can sit and move freely at the table. The work area – the public area – should be delimited by an architectural design that is easy to understand. The workplace should allow for normal work to be carried out without the user getting outside of the public zone unintentionally. The area outside the public zone allows for a person to pass comfortably behind the digital zone unseen.

Therefore:

Create a workPLACE with a desk with the space necessary for the performance of core activities, and those supported by the VMC with the necessary equipment. The space should have the focus point at a screen for VMC equipped with a desktop camera. Generate a radius from its approximate position, which indicates the outer limit of the table. Generate another larger radius, which delimits the *public zone* and has the same centre as the first radius. The difference in length between the two radii should allow for normal work to be carried out without the user getting outside of the public zone unintentionally. It should be possible for a person to comfortably pass behind or stay behind the digital space in the area outside the public zone unseen and unheard. Indicate clearly the border between the public and private zones, using architectural design.

The input to the system of images and voices should be strictly limited to the public zone, while the output might be experienced also from the private zone. If this is a problem it can be resolved by using, for instance, a headset and limited projection of images in glasses. The figure of the person at the digital workPLACE should be cut out and the background replaced with an image of an office environment or any other convenient one.



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Use the play with TAPESTRY OF LIGHT AND DARK (135), WORKSPACE ENCLOSURE (183) and CEILING HEIGHT VARIETY (190) to complete this pattern.

6.3 182b comTABLE

This pattern forms a part of a SEQUENCE OF SITTING SPACES (142) among the COMMON AREAS AT THE HEART (129), which is distributed within the grid of PRIVATE AND PUBLIC SPACES (127 b) in the home. It is a fundamental part of the FARMHOUSE KITCHEN (139), COMMUNAL EATING (147) and completes the EATING ATMOSPHERE (182).

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The activity of eating together is important for the unity of the family or a group of closely related individuals, and for the social upbringing of children. Getting together for a meal is often difficult nowadays due to the separation in space of the individuals.

The act of having a meal together is a cultural activity that is full of rituals and common experiences. Everybody "knows" how to have dinner. So, it is an activity that is best carried out in a shared environment, even if some of the participants are not physically present. An important part of the social upbringing of children takes place at the dinner table. Nowadays, however, it seems to be difficult to get together not only for dinner during the weekdays, but even for the traditional Sunday dinner. Parents may work very much and at irregular hours, the children may study elsewhere, grandparents and other relatives may live in other parts of the country etc. The *comTABLE* offers a complement to the physical participation of a person being at a remote place, who otherwise would not have been able to attend at all.

The comTABLE contains a flat screen, a camera, microphones and loudspeakers, which are all integrated into a mobile frame at one end of a dinner table. This arrangement permits all persons around the table to perceive the same image and it reproduces the remote person in a fairly natural size and position. The screen can be folded and hidden in the table when not in use. It is just as easy to use the table without the video communication. If a remote person connects with the table, he/she appears on the screen, but will not hear or see anything.

The remote person appears on the screen, still without seeing or hearing anything, when it is down...

When the frame is lifted and put in a vertical position the system connects the input devices to the guest and the person can hear and see what is going on at the table and participate in the dinner conversation.



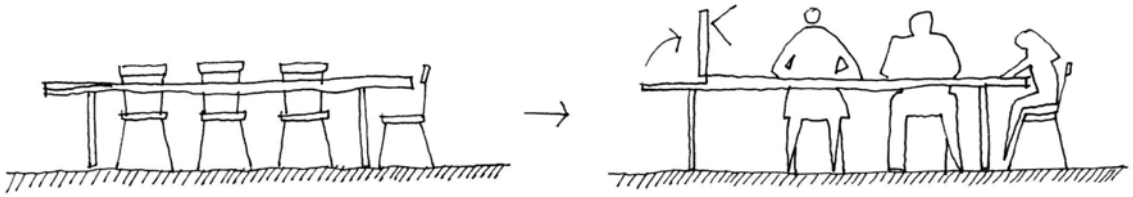
...and is invited to the dinner by the lifting up of the screen.

After dinner, the communication is terminated by the screen being folded down, and thereby the flow of information is stopped. By integrating the screen, camera, microphone and loudspeakers into the foldable part of the device, the control of the visual view and sound becomes very physical; a natural type of syntax for adjusting the public and private space of the comZONE. A comTABLE is a substitute for the dinner table and should be placed where

this is generally placed. The location of the table should allow for the light to be directed towards the persons around the table. The sun or strong light must not be directed towards the screen. For future designs we can imagine more screens around the table, several cameras and more complex sound-capture - and maybe even the transmission of smells!

Therefore:

A comTABLE should have an integrated screen that permits a person at a remote place to participate in the dinner (representation). The participation of the person on the screen should be easy to control (cf. opening the front door for a guest). Therefore the screen, camera, microphones and loudspeakers should be integrated in foldable frame. When the equipment is directed towards the ceiling, the remote person cannot see or hear anything. The screen should be placed in the rear end of the table, which permits the best view for the persons around the table as well as the person on the screen.



as a normal dinner table

with the screen folded up for a dinner with a digital guest

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Use POOLS OF LIGHT (252) to produce lighting that both supports the activity of eating and improves image quality for the remote dinner guest.

6.4 147 b mediaSPACE

This pattern supports the social interaction between THE FAMILY (75) and other family members and friends at remote places. It should be considered as the most public space within the INTIMACY GRADIENTS (127) and should be treated as one of the COMMON AREAS AT THE HEART (129) that are distributed within the grid of PRIVATE AND PUBLIC SPACES (127 b) in the home.

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Social and cultural events such as parties, weddings, anniversaries, celebrations, etc. are examples of a cultural heritage that should be kept alive. Ordinary everyday activities of a more aimless character are usually more stimulating to carry out in the presence of other family members or friends than by oneself. Nowadays, however, family members and friends live further away than ever. For political, economic or practical reasons, it is often impossible for many members of a family or a group of friends to attend both everyday activities and special social events. This can create isolation and tear relations apart.

People move around the world for work and for leisure more than ever. Friends and families often live far away, in distant regions and other countries. Many social activities take place without the possibility for everyone concerned to attend for economic, social, political or professional reasons. The mediaSPACE is created to permit participation at social events in spite of separation in space; the mediaSPACE is a digital social space. The metaphor for this

set-up is "a living room" for the presence of a remote grandmother or child at a more formal social event such as Christmas Eve with Santa Claus.

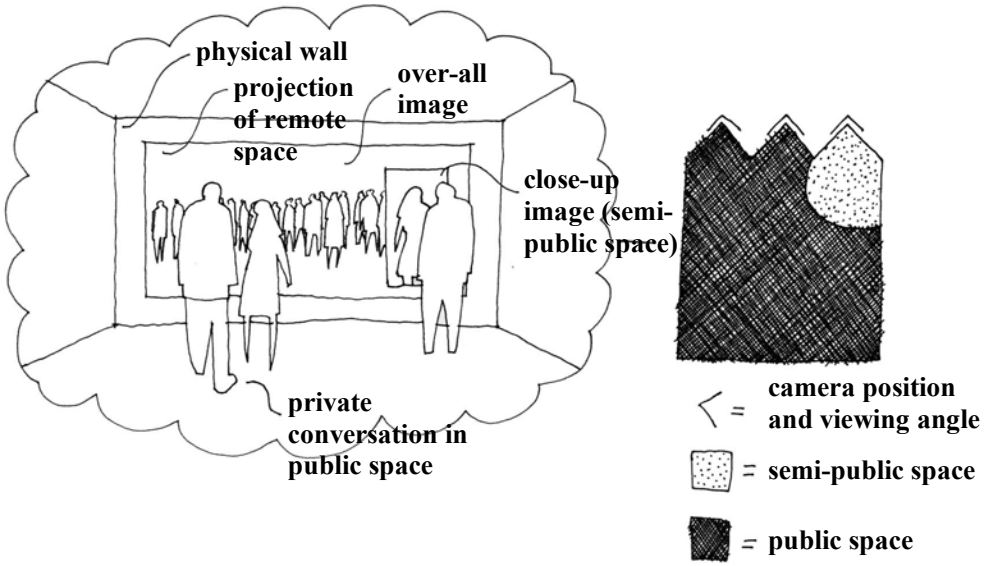
The remote participation at a wedding, maybe on the other side of the world

In everyday life, what people do when they spend time together is not in focus. Instead, the awareness of someone else being present in the social space is the fundamental point.
At anniversaries, weddings, christenings and (cocktail) parties etc, it is important to get an overview of the entire space occupied by the participants. It is equally important to have the possibility of a focused view of a specific individual or a smaller group of people. Thus, the mediaSPACE contains a large wall with a general overview projection of the whole space, and provides a possibility to get a more specific picture on a part of the screen, similar to a "window" covering a part of the background. The cameras are located at the media wall in order to generate viewing angles that are as natural as possible over the space. The sound system can be connected to the surround system of the room. The microphones are placed at the media wall in order to capture the general atmosphere of the sound on one hand, and to create places for more private discussions on the other hand. The user must, of course, be aware of this arrangement in order to carry out a more *private* conversation within the public space.

Therefore:

Create a system that is able to generate a large digital social space. It should consist mainly of a wall exposing wide landscape images, cameras to capture both overall images and close-ups, and microphones to capture both the overall sound and sounds from specific locations in the room. This can be done by placing a pictorial cut-out of a person or a smaller group within the framework of the large image, close to the border

to the large screen, for instance. It should be possible to get closer to the wall and have a more private talk with a remote person or a smaller group of people. This procedure has to be supported by the sound system, which must create a general background sound as well as specific directed sound for personal talk. The system has to be supported by at least one camera for the overall image. The image projected on the media wall must seem natural and should, if possible, not provide a distorted perspective. At least one camera is required for the support of the close-ups. The lighting is crucial and must be compatible with the technical design. Good general lighting from above, supported by lateral lighting is preferred. The remote site should have a similar set-up.



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To complete this pattern, consider the INDOOR SUNLIGHT (128), the SITTING CIRCLE (185) and THE SHAPE OF INDOOR SPACE (191), as well as the possibility to use WARM COLORS (250).

7 DISCUSSION

The examples above demonstrate how Alexander's design patterns could be applied in a specific setting and with a specific technical artefact, i.e. the home setting and VMC. The patterns have been constructed on the basis of the experiments conducted and the designs developed for the comHOME project. During the development work on comHOME and the patterns it has become apparent that a surprisingly large number of the aspects of the various

comZONES seems to be possible to generalise in order to support different aspects of video-mediated communication in the home environment.

Although the setting for this exercise is confined to a specific set up, comHOME, it offers a possibility to test the principle of Pattern Language according to Alexander's interpretation. The very nature of PL is explorative – it permits the development of new patterns based on hypotheses that have not necessarily been absolutely verified.

The following specific issues could also be mentioned:

- We are aware of the fact that our new patterns are not fully compatible with Christopher Alexander's Pattern Language as it was presented in 1977. By further adapting our patterns to his scheme in order to get a description that is as complete as possible, we will get a better insight into the very nature of our particular problem, in particular with respect to how the conflicts between new media at home are influenced by traditional floor lay-outs, and to what architectural and technical measures could be taken in order to reduce these conflicts and benefit from the challenges they offer.

- The work on *a pattern language* has encouraged further development in the area of intelligent buildings and smart homes. It seems, but still has to be proved, that the pattern language, which is all-embracing but vague and not very precise, could be a departure point for a more precise definition of a schema that leads to results that are clearer and can be used more directly. However, the criticism of Pattern Language would already and without doubt also be applicable to a more refined methodology that is based on the same hierarchical structure as Alexander's structure

- Several parallel design methods should be considered, at least for the scientific part of the work on the development of new patterns. Designing by developing *metaphors* ("a friend in the doorway", a "Sunday dinner", "a shared living room" or "a Christmas eve"), creating *scenarios*, e.g. by making a movie (Junestrand et al., 2000), and performing *user studies* (with intellectually disabled persons) have all been productive methods for us. They have also helped us to keep the designs close to systems which support basic aspects of everyday life and which ordinary people can use.

It should be added that the general approach of the research, which is briefly outlined in the introduction above and which includes the sciences of the artificial and the future orientation according to Dahlbom, does not obstruct the work conducted for the comHOME or the theoretical work presented here. On the contrary, although we have not in depth confronted the practical experiences with the more rigorous scientific framework, it seems that the scientific approach in all essential respects underpins the methodology that we have used in the practical experiments. This issue should naturally be brought up continuously and we will get back to this question later elsewhere.

8 FUTURE WORK

The work on the development of design ideas for the comHOME flat is carried out continuously. A user study with a number of intellectually disabled and non-disabled persons was carried out in comHOME in the summer of 1999. This study is now being structured and analysed. Furthermore, an experimental video with professional actors demonstrating the different VMC set-ups in the social context of everyday life was recently recorded in comHOME (Junestrand et al., 2000) and it is used as a basis for supportive discussions about the work. Improvements and redesigns of the comZONES are under way, as well as a further integration of the VMC with a smart environment system that now functions separately.

The design principles of the design patterns presented in this paper can be introduced in real flats, as well. A housing company will apply these principles to a multi-storey residential building in southern Sweden, in connection with a housing fair during the year 2001.

9 ACKNOWLEDGEMENTS

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