

# Bespoke Appliances for the Digital Home

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## Abstract

The arrival of the digital home brings both new opportunities and challenges for the systematic development, testing and iteration process for bringing meaningful, products to a global market. In this paper we describe a method being used by Intel to address this complex issue; Consumer Experience Architecture (CEA). We discuss how the CEA may be applied to the introduction of radically new concept for future digital-home appliances called meta-appliances in which traditional appliance and applications are deconstructed in a way that consumers can reassemble them to create bespoke appliances for their digital homes.

## 1. Introduction

This paper outlines a process for taking theoretical and experimental computing concepts and applying them to a systematic development, testing and iteration process to bring meaningful, products to a global market. As an illustration we use the concept of MAPs (MetaAppliances), placing this into the process of Consumer Experience Architecture as a means to develop the concept into devices and applications for digital homes that can be developed by industry. The CEA process also provides a means to comprehend real world opportunities and barriers to adoption in the development of the MAPs concept. Here we use the CEA framework to capture and formalize these insights into product specification documents. Additionally we explore the use of the iSpace facility within the University of Essex Digital Lifestyles centre (DLC) as means to examine and iterate the consumer experience of the MAPs theoretical concept. The unifying thread throughout this paper is the consumer or end user. The human perspective of the user drives and is at the centre of the CEA process. MAPs applications are entirely created by the end-user to fit seamlessly and productively in their daily lives. The iSpace focuses on the active involvement of the user in the innovation process, opening up the opportunity for unexpected results and innovation. We believe this unique combination to be key to the development of successful innovative products and services for the home environment.

## 2. MAPs: An Overview

There are many visions for digital homes that speculate on how network services might change the natures of consumer products and peoples lifestyles. One example is a concept called MAPs (meta -appliances and applications), 'soft objects' that provide a means to aggregate elemental network services together to create virtualized forms of regular and novel (user created) appliances [Chin 07]. By way of an illustration, a regular TV MAP would consist of a combination of a "display", "audio", "media stream" and "control" service. Such elemental services might be provided as alternatives to appliances of today, or extracted from networked connections to regular appliance that currently populate digital homes. In addition to defining service membership, MAPs also contain rules that determine how the services coordinate actions to provide the behaviour of the virtual appliance (a TV behaviour, in the example given). Novel MAPs might even be created and traded by new kinds of appliance manufacturers or by suitably motivated end-users as a new form of "Do-it-Yourself" (DIY).

In section 4, we discuss this in more detail, in particular discuss the technical needs for MAP based digital home systems.

## 3. Consumer Experience Architecture: An Overview

Consumer Experience Architecture is a practice and a methodology for the development of products within the currently accepted product development cycle. Consumer Experience Architecture (CEA) provides a means for multiple inputs into the product design process; including computer science, theoretical computing and social science research as well as traditional market analysis, demographic profiles, technological surveys and competitive analysis. Additionally, the framework provides industry the ability to identify, document and validate specific experience metrics, derived from these multiple and varied inputs. CEA's holistic approach keeps the desires and needs of the end user at the center of the process and allows development teams to not only gather and take advantage of innovation but it can validate the application of these ideas throughout the development process.

At a meta-level the CEA framework can be divided into four discrete and distinct stages. Each stage serves as a key point of intersection, influence and iterations in the development process.

**Stage 1: Experimental and Theoretical Insights**

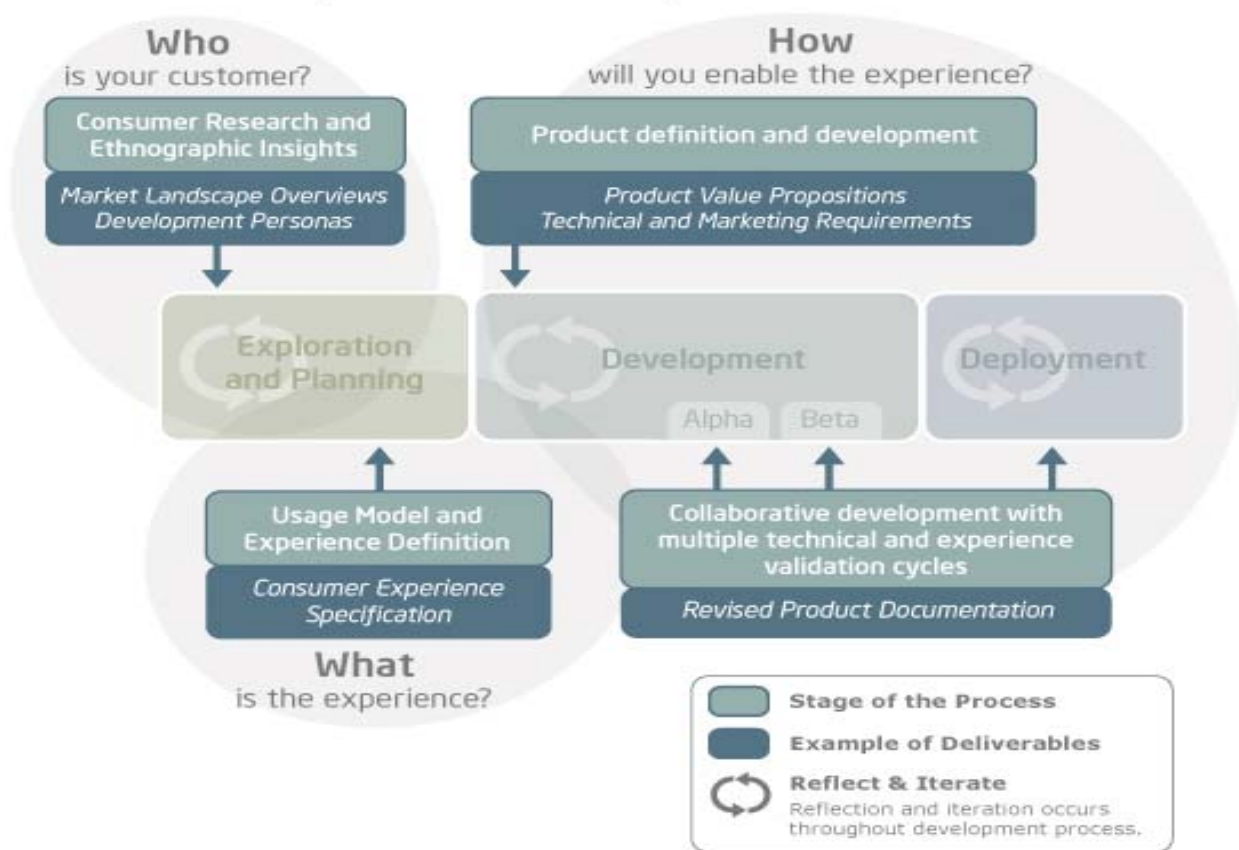
The initial research and information gathering stage of this framework provides input into the planning cycle. Here scientific experimentation and insight, such as the MAPs concept explored above, is coupled with market and competitive landscape data as well as consumer needs, interests and concerns. Because in affect the end user drives the CEA development process, an industry product team can develop a deep and well rounded vision of the end user needs and reservations. At this stage the insights are used to influence the early design of a product or

beyond traditional planning documents and can be utilized for further definition of business models and go-to-market plans that are so important for the financial and funding portion of product development.

**Stage 2: Experience Definition**

As the planning cycle moves forward and the product offering becomes more defined, a set of documents are created that outline the specific consumer experience that the product or service. These documents have a particular resonance as they are based on academic experimentation and real world consumer insights. In fact, it is the combination of these insights into a single document that is ultimately focused on delivering a specific set of experience to the consumer that makes the CEA process so effective. This stage provides the opportunity for every

**Consumer Experience Development Process Overview**



**Illustration 1:** CEA framework

system. The MAPs examples illustrates how consumers would find joy in the “decorating of their digital space”, meaning there can be an inherent joy in the act of setting up ones home, personalizing it and getting it perfect. Likewise it highlights possible barriers for consumer adoption. Here we would draw on both physical home improvement and decorating activities along with personalization in the digital space. These insights go far

member of the industry development team to gain a holistic understanding of the desired consumer experience. As stated previously, consumer experience is the sum total of multiple inputs or influences on the consumer understanding of a product. All of these inputs serve to form a mental model for the consumer. It is this mental model that we can use to construct and develop a solid experience that will be both usable and desirable. It can

also be used to address any barriers that need to be overcome to empower the consumer's adoption and usage of the product from the technical developers to marketing team, this knowledge proves to be invaluable as the development cycles move forward. It provides both a base of knowledge from which each team member can draw upon to inform their specific domains in the design process but also this knowledge becomes a shared understanding between all team members. Additionally, it gives them a shared goal that has been documented and can be returned to for wider problem solving activities of even broader corporate or business group alignment.

### **Stage 3: Early Product Definition**

Once the experience opportunities have been identified and the desired consumer's experience mapped it is necessary to deconstruct these opportunities into usage models and values propositions. Usage models are an industry accepted standard format for the development of technology specifications and prototypes (reference).

From the experience opportunities and usage models we then develop the product's value propositions. These value propositions act as an expression of the product to the consumer, using their own language. Documenting these value propositions in consumer specific language is an essential part of the framework. This step in the framework also serves as a point of reflection and iteration. It allows the team to make minor adjustments in the experience that is being developed. This articulation can serve as a way to discuss the attributes and value of the product to people both inside and outside the development team. As with the MAs illustration, the team can build off the strengths of the concept and address the barriers when interacting and testing the product in Stage 4

### **Stage 4: Production and Validation**

The final step in the CEA framework is the longest in duration and the most complex in execution. During the product development and validation cycle the team applies a user experience (UX) validation process or UX process throughout the entire production process. The UX process encompasses a variety of systematic methods employed to evaluate and understand people's perceptions and experiences with the product, throughout the product lifecycle. UX's targeted methods examine the user experience with concepts, prototypes, and functional product. UX is not market research or focus group testing, but rather assessment of people's actual interactions with a prototype or product of some sort.

At each key milestone in the development process (e.g. prototypes, alpha, beta, and release candidates) the team uses UX to validate that the original consumer experience goals are being met by the product. The test protocols for the UX validation are based upon the core documents of the consumer experience framework. The experience specification clearly articulates the experience needed to

resonate with the consumer. Utilizing the social and research insights from the previous stages the CEA specification can also describe the test environments such as where in the home a device might be used or how it might integrate into the consumers life. Additionally this information can explore how the product should present itself to the consumer. Even the value propositions can be tested to see if they do indeed have value to the consumer and if the product is meeting the promise of these propositions. Likewise possible solutions to overcoming adoption and usage barriers can be developed, tested and iterated.

The UX validation process provides iterative feedback directly from the consumer as to the successes and failures of the product. By performing this validation process multiple times throughout development and basing all stages on a consistent framework UX allows the development team to refine the product multiple times to meet the original experience opportunities outlined for the product.

The results of the UX validation process are not only valuable to the development team. The iterative results of this process, coupled with the experience documents from previous stages of the framework provide a clear and compelling picture of the product even before it has been shipped. The results of the UX validation can provide clarity to upper management, possible partners as well as the investment community.

## **4. MAs and creating consumer designed bespoke appliances**

As explained in the introduction, a MA is a soft-object that represents a virtualized appliance. It works by providing a means to aggregate elemental network services together so as to form regular or novel appliances composed of collections of network based services (some originating from "real" appliances plugged into the digital home network).

More formally, a MA has a set of primitive properties and a collection of rules that determine the behaviour of the coordinating devices and, as a consequence, the behaviour of the virtual appliance. Rules are essentially a marriage of two different types of actions, namely 'Antecedent' (condition) and 'Consequent' (action). Each action (whether it is an 'Antecedent' or a 'Consequent') has the property of a "virtual device". The 'Antecedent' of a Rule can be described as "if" while the 'Consequent' of a Rule can be described as "then". A Rule can contain 0-n 'Antecedents' and 1-n 'Consequents', and a MA legally can contain 0-n Rules (as Rules can be added later by the end user). In computational terms Maps may be regarded as non-terminating processes (or tasks). Until a MA is terminated, it will retain the functionalities that the user originally created (ie. it is a continually running process).

A key consideration is how MApps are created. Chin has raised this issue and makes a strong case for non-technical end user methods which she sees as a key requirement to empowering the principle stake-holder of the digital home to engage with the technology [Chin 06 -1 ]. She points at two solutions, one based on highly automated autonomous agents which monitor people's behaviour, using this historical information to build models that aim to configure the technology to meet the person's future needs. She argues that such approaches have drawbacks such as a reluctance of many people to allow their personal home spaces (and them) to be monitored by networked connected technology in this way and, second, that trying to second guess needs based on past experience will inevitably have annoying failures (as not all future needs will be described by past actions) and it doesn't allow creative thoughts for novel MApps that might exist in people's mind to be efficiently extracted. For those reasons she has argued for, and produced a prototype system referred to as PiP (Pervasive interactive Programming) that users can use to create Maps by demonstrating, in explicit teaching sessions, the behaviour they require [Chin 06 - 2].. The full technical details and needs are given in [Chin 07].

**5. iSpace: An environment for User Experience Testing and Iteration**

Utilizing the CEA framework, we would capture the MApps theoretical insights, coupled with social science insights around consumer behaviour in a home environment. This foundational document identifies both the desired consumer experience and the possible barriers to adoption and usage. As the industry team begins to develop the product it will be necessary to utilize an UX

environment to test and iterate the product's key consumer touch points. Does the consumer have a mental model to understand the MApps concept? Do they understand how to create MApps (eg apply PiP methodology), do they know how to interact with the product or service? Will they allow this technology in their home? What is their perception of the value of the product? A key component of the CEA framework is to build, test and iterate these key issues in an environment where the total user experience can be evaluated. The iSpace facility within the University of Essex Digital Lifestyles centre (DLC) provides just this space with the user firmly at the centre of the innovation process.

The DLC is a member of the European Network of Living Laboratories, an EU initiative to coordinate the development of a European Network of Living Labs. Together the partners join forces as a network, to develop and offer a gradually growing set of networked services to support the "Innovation Lifecycle" for all actors in the system: which can include end-users, SME's, corporations, public sector and academia. This is grounded by involving people during the course of their everyday lives and treating the users and user communities as contributors and co-creators of new innovations. The iSpace Living Lab is at the heart of the DLC. This new apartment makes possible ubiquitous networked sensors and actuators, the infra-structure for which is accommodated within the specially constructed walls, so that the heterogeneous networking infrastructure is hidden from view.

Designed to provide a flexible test-bed for research into digital homes and adaptive environments within a pervasive and ubiquitous computing context the iSpace offers the possibility for examining the deployment of

# Positioning tools & techniques.....

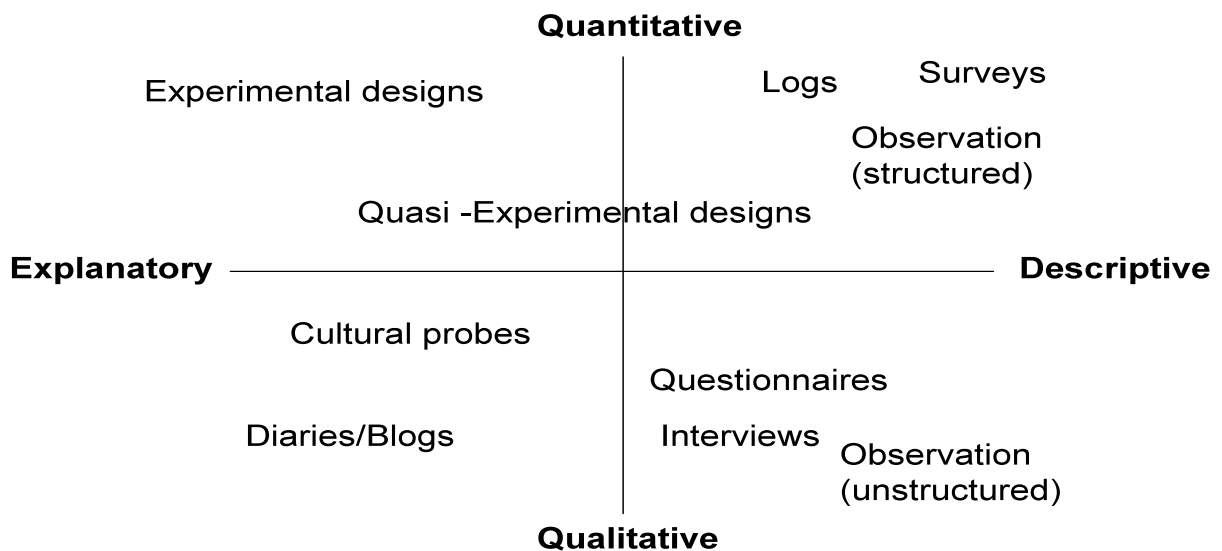


Illustration 2:- Positioning Tools & Techniques

embedded agents and sophisticated user interfaces within the intelligent environments of tomorrow. Researchers are able to deploy the latest technology to enable autonomous agents to monitor that learn from user behaviour together with end-user programming techniques to provide systems to particularise their behaviour to the building's user in an unobtrusive way where the user is always in control. At the same time the iSpace allows those concerned with the social-technical research into the preferred interfaces and user defined development of virtual devices to explore this space with sensitivity and control. The iSpace has been designed to allow research into the widest range of possible user scenarios, including able bodied, disabled and elderly populations with a view to maximising the possible benefit of the new technology for all sections of the community.

The iSpace fills a void in the gap between Human Factors laboratories which are highly controlled but artificial environments, and end-user technology trials which can be highly realistic (as they take place in the user's own home) but are difficult and expensive to setup and control. The aim of the iSpace is to offer a highly naturalistic setting in which users can live for extended periods of time (from a few days to a few months), and also be highly configurable for evaluating a wide range of 'lifestyle' applications. For these reasons the environment is perfect to evaluate the Maps and PiP concepts discussed in this paper.

The iSpace can be combined with different tools and methods to support the different stages of the CEA process. For example it can be used to carry out basic research to refine marketing propositions, or used to formatively evaluate early prototypes of new services, through to the final validation and refinement of finished products. To this end we are developing a number of tools and techniques to support these evaluations, which can combine both descriptive and explanatory analysis, using both quantitative and qualitative approaches to data capture. This quasi-experimental 'Living Lab' approach attempts to bridge the divide between the high internal validity but low ecological validity of traditional experiments, and the high external validity but low internal validity of full scale user-trials. Within this remit it is then possible to position a range of tools and methods which can serve different purposes in the evaluation of products and services. (see Illustration 2).

One critical issue with the Living Lab approach is to remove the reliance on the researcher as the main instrument for interpreting the behaviors exhibited by users living in this environment (this is true even in ethnographic studies which are still rooted in the discipline and interpretation of the evaluator). Instead, we are looking to empower the users themselves to self-analyse their experiences (this is particularly important for MAs which are entirely user created and configured). For example, we have used Dervin's Sense-Making [Dervin, 1983] approach as a means of enabling participant driven structured reflections. Following a period of initial user

training, this has been used to help the participants focus on issues arising from the use of technological solutions, and highlight the external circumstances that were present at the time, and the internal sense-making process that they went through in order to resolve any of these issues (based on a micro-moment time-line interview and 'gap' reflection by DLC evaluators) and identify previously unforeseen phenomena. This has been particularly useful in highlighting usage issues arising from a range of advanced communications facilities within the iSpace. The use of PiP in the process of consumers creating MAs gives a natural view of this user driven process.

A similar approach is based on the use of cultural probes [Gaver 1999] where participants have used a range of different techniques (eg. self-directed photography, labeling, diaries, pictures, etc) to capture issues arising from extended user studies. This has been particularly useful in assessing more 'subtle' issues such as access to private space and conflict over control of shared resources. It also provides a method for eliciting information on issues which can often be taken for granted or fairly sensitive (it can handle anonymity & privacy issues) and is a good form of participatory design. This Living Lab approach has several benefits. So far it has been used to validate an existing product set with a leading telecoms company, and to test early prototypes of new imaging services with a leading digital imaging company. This includes carrying out pre-product user behavioural studies where the iSpace provides a test bed for a range of focused research activities. This living lab approach adds a whole new level of 'dynamism' in the use of the CEA architecture – where it is possible to iterate around the CEA stages very quickly.

## **6. Decorating your Digital Home or has your toaster become big brother?**

The CEA framework combined with the user experience testing in iSpace provides a process to both test the foundational concepts of MAs and also allows for iterative changes and improvements to the product or service. It is important to point out that the process described in this paper places the end user as the unifying theme throughout the framework. The user creates MAs, the user is at the centre of the CEA process, and the iSpace/Living Lab approach involves the user in the co-creation and innovation of new products and services (Chin 06 -1). This process provides users with bespoke products, to where the user creates their own unique products based around the MAs concept. With this scenario of user freedom and empowerment we expect to see more user-disruption in the development process as well as unexpected results and innovations

As identified above, a key component of the MAs concept is the consumers' mental model. Will the consumer value MAs? Will they have a frame of understanding to reap the product's benefits? What is the best means for the consumer to interact with the system?

Are there specific barriers or worries they might have about the adoption of the system?

The CEA's experience specification is the foundational document to capture these questions. Using both social science models of current customer behaviour around home and computer science user interaction models these questions can be explored and refined. The follow outlines possible areas for exploration and testing:

### **Making your home safer**

The home is both the site of safety and danger. The system could be employed to maintain the investment of the house and the safety of its occupants. Expanding the current model of home security, a range of "security" or "safety" MAPs could be presented as an extension of a home monitoring system. In this way the system is not seen as intrusive but acting on the behest of the consumer to protect the home and family when the consumer cannot. Home monitoring and security is seen quite differently when the emphasis is protecting the value of the consumer's property and aiding them in the safety of their loved ones.

### **Greening your home**

With the rising awareness of global warming and environmental concerns, a range of "Green" MAPs could be seen as a way for the consumer to not only save money but be a more responsible user of energy. This social consciousness coupled with the fierce personal customization of MAPs could position the technology as a way to not only save money but also do the the right thing for the planet.

### **Customize your digital home just like your email**

One aspect of the power of the internet and connected devices is the area of personalization. Consumers are comfortable with the idea of customizing their news and social networking sites. MAPs could provide a mechanism that allows consumers to personalize the functionality of their digital homes in the same way they personalize their online lives. These personalized templates could be shared with other family members or more widely via the internet

## **7. Conclusion**

The application of the CEA process to the innovation of MAPs clearly illustrates how theoretical and experimental computing concepts can be brought to industry. We propose that the CEA process can bridge the gaps of the theory and experimental iteration and refinements to bring more meaningful and insightful products to market. Because the consumers' interests and desires are at the center of all three concepts a whole new category of user

developed bespoke products could be created for the home.

Finally, it is interesting to reflect on how the digital home market might be altered by the introduction of MAPs. On the one hand the consumer is empowered to specify the functionality of the digital home, rather than just relying on manufacturers to predict and deliver the right functionality. In turn, the manufacturers, by "harvesting" the consumer created MAPs specifications, have a convenient form of market research that specifies more exactly peoples needs and behaviours and can focus better on the appliances and services that are needed. In other ways MAPs might also invigorate the consumer market as customized MAPs that catch people's eye, might require them to buy extra appliances or services in order for a given Map to function correctly. Undoubtedly PiP and MAPs offer an exciting vision for a future where consumers will be empowered to create their own bespoke appliances; as ever however refined our research methodologies are, the ultimate judge of a products value remains the consumer which the CEA architecture seeks to connect with.

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