# A Toolkit for User Re-Configuration of Ubiquitous Domestic Environments

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**ABSTRACT**
This paper describes a distributed system with the aim to allow inhabitants to re-configure arrangements of devices and to understand the behaviour of these devices in tandem by making visible the various configurations. The purpose is to address the evolutionary nature of the domestic environments. We describe two different configuration facilities and the underlying infrastructure.

**KEYWORDS:** Domestic Environments, Ubiquitous Devices, Configuration Toolkit

## INTRODUCTION

An essential element of domestic environments is their evolutionary nature. Domestic environments are open to continual change and the need to support this change is essential to the successful uptake and management of digital devices in domestic spaces. Previous studies have highlighted how inhabitants continually reconfigure domestic spaces and the technologies within them to meet particular demands [2]. Similarly, architectural historians such as Brand [1] have highlighted the importance of change to allow inhabitants to appropriate domestic spaces and make them their own. As Brand observes, if the cost of altering services is too high then inhabitants have previously demolished buildings and rebuilt.

## MAKING DIGITAL DEVICES INTO EVERYDAY STUFF

In developing technology to be placed within the home we need to make sure it is handled as stuff (using Brand's terms) that is open to continual change. If the cost of reconfiguration is too high then these devices are more likely to be considered as part of the services of the home rather than as the everyday stuff that is routinely used and exploited by its inhabitants. The net result is that as the needs of users change over time the use of these services will decline.

To ensure that digital devices are treated as everyday stuff we need to open up access to the supporting infrastructure that connects devices and provide users with a simple user oriented model that allows them to mange the introduction and arrangement of new interactive devices. We have developed a system built upon a component-based model that seeks to exploit a distributed shared state model to allow the rapid composition of devices to meet the everyday interactive arrangement of the home. Each component makes a number of different properties available across a distributed dataspace. The aim is to allow inhabitants to compose arrangements of these by linking devices and to understand the behaviour of these devices in tandem by making visible the various links between different elements within the home.

## A COMPONENT MODEL FOR HOME ENVIRONMENTS

The basis of our component model is the notion of a shadow digital space. This shadow digital world acts as a "virtual" representation of the physical environment and allows real world devices to make information about the nature of the physical environment digitally available. Devices can use this shared digital data space to become aware of their context, represent this contextual information to other devices and to make this manifest in the physical world. The aim of devices within the physical environment is either to make information from the physical available within the digital or to make digital information have a corresponding physical manifestation. This general model is shown in figure 1.

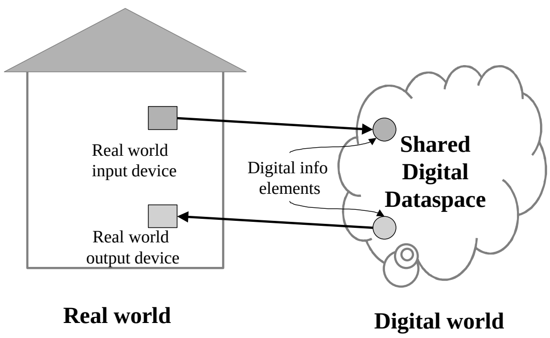


Figure 1: The basic component model

The fundamental aim of components in this arrangement is to ensure the convergence of the physical and the digital environment. Thus each component can be thought of as a **digital/physical transformer** that provides a conduit between the real and the digital. Each component has a set of properties that it uses to make information digitally available. The values of these properties are shared through a distributed data space. The dataspace is dynamic and reacts to changes in the values of properties; propagating these changes to all the components that share these properties. There are three main classes of components.

*Physical to Digital Transformers* take physical effects and transform them into digital effects. Any particular device may make use of a number of transformers. Essentially each transformer measures a physical effect and transforms it into a corresponding digital property that is shared through the dataspace.

*Digital to Physical Transformers* represent the complement set of transformers. Their job is to make digital information physically manifest in the real world. This class of components transforms the values of shared properties to drive some sort of physical device.

*Digital Transformers* act upon digital information and effect digital information. This class of components provides a way to present to users deeper semantic reactions to changes in the environment.

## THE DEVELOPED TOOLKIT

Our developed toolkit is based on a shared dataspace, a TupleSpace called Equip. It allows us to share components, their properties and links between these properties. A set of configuration facilities exists to modify the arrangement of components and the links between these.

### The Configuration Facilities

Once properties associated with transformers have been placed in the shared dataspace they become available to users. Transformers are linked together by binding the various properties together. Essentially, two properties of the same class (e.g. text, id, URL) can be bound together and whenever a property value changes all of the properties bound to that property change. This allows the chaining together of transformers. In order to compose arrangements of transformers needed to link devices the toolkit currently provides two different initial ways of binding properties together, the Composition Editor and the Linker Device.

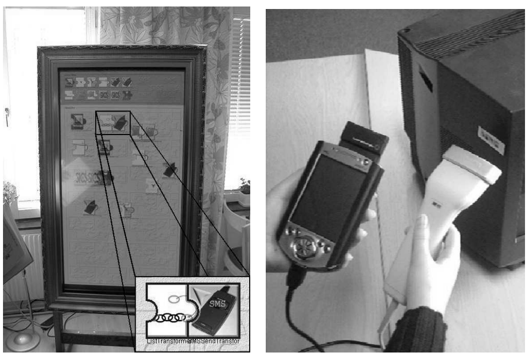

Figure 2: The Composition Editor and the Linker Device

### The Composition editor

The composition editor uses a screen based graphical display. On the upper part of the screen the editor shows the currently available transformers, each represented as a puzzle piece. These are dynamically updated whenever a new component is shared within the data space. On the lower part of the screen is the workspace where different transformers are linked. By attaching the transformer representing the kitchen cupboard to the SMS sender transformer, an SMS is received each time a grocery is missing in the cupboard. The internal change of a property, is highlighted in the puzzle piece thus the user gets a view of the activities within the home.

### The Linker Device

The linker device takes an alternative approach to the composition and linking of devices. Rather than provide an overview display that shows the devices and transformations in the home as an abstract graphical representation, the linker device seeks to use physical manipulation within the setting as a means of exploring the properties a device makes available to the dataspace and as a means of linking properties on one device with properties of another.

The basic device consists of an iPAQ that connects directly to the shared dataspace and a barcode reader that can read barcodes placed on interactive devices. When the user scans a barcode the linker device queries the dataspace as to which properties the device has made available.

The user can select a property and see what devices it is linked to or can choose to link the property to a property associate with another transformer. In order to do this the user can find all of the Digital Transformers available which have appropriate properties in the system and link the selected property to one of them. Alternatively, the user can scan a second physical device bringing up the properties whose type match the selected property. The user can then select the destination property establishing the link.


## ACKNOWLEDGMENTS

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