# End-User Programming for the Home: a Challenge

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## 1. Introduction

Ubiquitous computing promises unprecedented empowerment from the flexible and robust combination of software services with the physical world. For the HCI research community, this means that end-users will be able to shape their own interactive spaces and build imaginative new forms of interaction and functionalities that were not anticipated by the system's designers. This means providing end-users with the capacity to "program" their interactive spaces including their home. This vision sounds very attractive. But to hold the promise, we need to find a way to master the intrinsic complexity of networked artifacts. To demonstrate this complexity, I propose to use an analogy with chemistry where a smart artefact is modeled as a composition of physical and digital atoms whose configuration evolves under particular conditions. A more detailed description is available in [Coutaz 08].

## 2. Smart Artefacts as Chemical Molecules

A smart artefact (also called a mixed-reality object or an augmented object) is a chemistry-inspired assembly made from two sorts of elements – digital atoms (D) and physical atoms (P) whose bonds correspond to communication mechanisms or physical attachments. As in chemistry, reaction (or a chain of reactions) results from the confluence of particular events, and produces new smart artefacts. A smart artefact may break down into simpler artefacts and atoms, or it may be coupled with other artefacts and atoms into a more sophisticated artefact. Alternatively, only the internal geometry of the artefact may evolve. The confluence of events that provokes a reaction denotes a change in context as introduced by the ubiquitous computing community. These events are generated either by humans, by the physical environment, or by the system itself (to guarantee service continuity, for example).

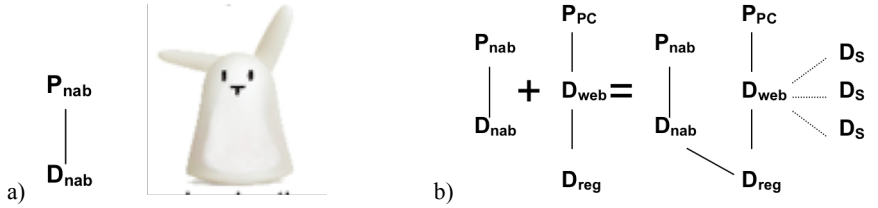


**Figure 1. a) The "virgin" Nabaztag as a [P – D] molecule**. b) **Registrating the Nabaztag. (Dashed lines denote couplings that result from a chain of reactions.)**

Thus, the simplest smart artefact is composed of a single D atom coupled with a single P atom. Software services are composed of D atoms only, whereas conventional objects of the real world are strictly built from P atoms. *An interactive space (e.g., a smart home), may be a unique macro-molecule of D and P elements*, *or it may be a set of molecules each one defining a smaller bubble, but prone to reconfiguration.* As in chemistry, the nature of the events that trigger a reaction has an impact on the resulting product. The Nabaztag shown in Figure 1 a) is an interesting form of [P – D] molecule. We have two of them at home. We like them, but in the future, we may get into trouble if the home becomes a huge molecule of smart artefacts!

## 3. The Nabaztag Exemplar

The Nabaztag is an information appliance[1] that results from the binding of a P atom with a D atom: the $P_{nab}$ atom is a 9 inches tall plastic bunny shape including a loud-speaker, moving ears, colored lights that pulsate on its nose and belly, and a

[1] Nabaztag means "rabbit" in Armenian.

Wi-Fi card. Its $D_{nab}$ atom implements some service-oriented protocol over IP. The [$P_{nab}$ – $D_{nab}$] molecule shown in Figure 1-a, corresponds to the "virgin" Nabaztag as users get it from the store. To become a working information appliance, the Nabaztag must be registered using a Web server on a personal computer. The registration process is supported by the [$P_{PC}$ – $D_{web}$ – $D_{reg}$] molecule where $P_{PC}$ denotes the PC, $D_{web}$ the Web server, and $D_{reg}$ the registration software service available from the Web server (see figure 1-b). By filling in forms on the PC, the user provokes a reaction between the original Nabaztag molecule and the registration molecule resulting in the creation of a bond between atoms $D_{nab}$ and $D_{reg}$ as well as bonds between $D_{web}$ and the $D_s$ services to which this particular instance of Nabaztag is able to subscribe. These services include weather forecast, time, inter-personal messaging, mood expression (the rabbit has a mood!), breaking news, etc.

Through form filling, the user can specify which services are of interest. Once the user has disconnected from the web server, the Nabaztag, as an information appliance, is a rather well-balanced star-like molecule with a stem coupled to a single P atom (see Figure 2-a). This simple real-life example illustrates one problem (at least): Users may be uncertain about the semantics of the final molecule. How can users be sure that the final boundary of the Nabaztag is the "nice" molecule shown in Figure 2-a? It is possible that the $D_s$ atoms are coupled with other services whose behavior may have an undesirable impact on the native $D_{nab}$ (for example, in terms of privacy). You can marry your Nabaztag to another one. If this function is transitive, your Nabaztag becomes polygamous. In other words, consequent bonds are created between your Nabaztag and other Nabaztags and this is unknown to you. As another example of chain of reactions, the arrival of the Nabaztag in the home, which may be a huge molecule or a set of coexisting molecules, may entail a chain of reactions that may not be predictable or even observable and controllable.

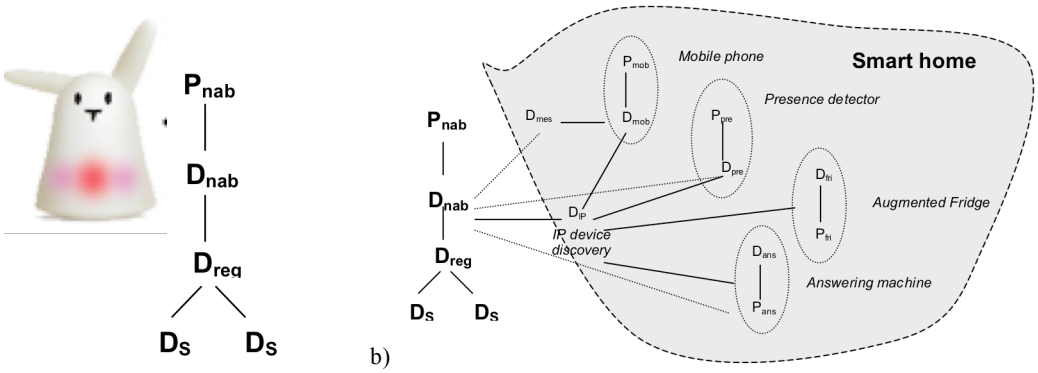


**Figure 2. a) The Nabaztag as a working autonomous information appliance. b) The Nabaztag joining a Smart Home.**

Suppose for example, that the Nabaztag joins the smart home represented by the molecule shown in figure 2-b. This smart home is equipped with a presence detector, a surveillance system, and an IP-device discovery facility. It includes a number of smart objects such as an augmented IP fridge and an IP answering machine. When the owner is away, any intrusion or abnormal situation is notified to the owner via the mobile phone. Suppose that the user has subscribed the Nabaztag to the buddies messaging service. The Nabaztag is then able to play messages sent by buddies using its speaker-phone. Unfortunately, it has no replay facility. Thus, when there is nobody home, messages are lost. In order for the Nabaztag to forward incoming messages to the recording facilities of the home, additional bonds must be created between the appropriate D services. These can be created autonomously by the smart artefacts, or they can result from the interpretation of an end-user program, or from a smooth combination of both. Whatever the process, an initial coupling is necessary to entail a chain of reactions until reaching a stable appropriate situation. Because the Nabaztag is an IP device, a bond can be automatically established between $D_{IP}$, the IP-device discovery facility and $D_{nab}$. $D_{nab}$ is now able to discover $D_{pre}$, the presence detector, as well as $D_{rec}$ to use the recording facility of the answering machine or even $D_{mes}$ to forward messages to the mobile phone. These bonds can in turn provoke new chains of reactions. How far can we go? The complexity is combinatorial, even for very simple situations. This is the problem I would like to develop and discuss at the workshop. Even if we manage to define the appropriate notations for end-users to program their house, we still have to solve the semantic boundary problem.

[Coutaz 08] Coutaz, J. End-User Programming and the Intrinsic Complexity of Networked Artefacts. Submit to the 4th Workshop on End-User Software Engineering, ICSE 2008.