Non-homogenous Network, Control Hub and Smart Controller (NCS) Approach to Incremental Smart Homes

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Abstract. The rapid increase in memory and processing power of even simple devices is opening up new opportunities for intelligent devices and environments. However, major barriers exist to practical limitations. Many "smart environments" are currently more complex to either set up or operate than their predecessors. Environments which are simpler to use are often very complex to set up. They also often require wholesale re engineering of the environment. Proposed is a model for using a mixture of non homogeneous network technologies, a control hub and a smart controller to provide a way for users to slowly transition both themselves and their houses from current technologies to smart technologies and environments.

Keywords: Remote user interfaces, task-based user interfaces, digital home, usability, accessibility, Universal Control Hub, Universal Remote Console.

1 Introduction

The rapid advances in technology are allowing us to create products which have increasingly complex control systems. This can either be used to make products more intelligent and simpler or to add features and functionality. Although progress is being made on both fronts, the later is winning out over the former. For those looking for increased functionality and able to handle the complexity this is a positive development. For those who have difficulty dealing with technology and complexity to begin with, it is creating a crisis. Simple versions of products are disappearing and being replaced by complex, multifunction products, or even simple products with numerous additional options, setting and features.

This problem is not restricted to a small portion of the population. Increasingly the problem is being faced by consumers in general. This is also being reflected in the usability and return rates of consumer electronic products. It is widely acknowledged that complex user interfaces are an impediment for the proliferation of the digital home. "Ease of use" is the third most important aspect for home theater owners, only narrowly topped by "video quality" and "sound quality" according to a recent CEA study [1]. In the same study "ease of using remotes" was the second most important

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aspect for these owners (ratio of the percentage of satisfied consumers and the percentage of those rating the attribute as important).

This lack of 'ease of use' is now directly impacting purchasing (and return) behavior. Two out of three Americans have lost interest in a technology product because it seemed too complex to set up or operate [2]. And the net profit on actual sales is now being cut down by the high percentage of products that are being returned. Den Ouden [3] found out that half of all 'malfunctioning products' returned to stores by consumers are in full working order, but customers cannot figure out how to operate the product. "No Defect Found" return rate runs as high as 90%+ (depending on product category) with consumer electronic returns costs estimated at $10B annually [1].

Philips Electronics North America's CEO Zeven reports that only 13 percent of Americans believe technology products in general are easy to use [2]. Experts have suggested having new products tested by older persons as a litmus test for ease-of-use [5]. The answer to the question "Can grandma figure out how to use it?" is a good hint for a product's usability in general.

1.1 Intelligent Homes and Intelligence in the Home

Smart homes, or just increasing the intelligence of products in the home, can help address these problems. Rather than trying to figure out how to use intelligence to add new functionality the goal should first be to make those things that people are already doing simpler. It is common for humans to first embrace new methods to achieve known tasks or to learn new tasks using old methods or tools. It is much more difficult to master new tasks and new tools simultaneously. Similarly, people are much more prone to embrace increased intelligence in their homes if it helps them to do things they currently find difficult, than if we attempt to introduce new technologies (which are more complex simply because they are un-familiar even when they are not more complex in an absolute sense.) Given the current usability crisis, the opportunity to introduce intelligence into the home has never been greater, if it can in fact make things simpler.

There are a number of barriers however in introducing intelligence into people's homes. These include:

1. Non-homogenous product technologies
2. Non-homogeneous network and connection technologies
3. Lack of interoperability even within products and technology bases
4. Investment to get started
5. Lack of transition path from existing products to smart products
6. Compelling reason to make change.

The challenges here are substantial. Developments in 4 areas however are now giving us the tools to begin addressing these issues. This paper explores the issues and then proposes a model that builds on these four developments to create a program that allows for the incremental incorporation of intelligence into the home in a fashion which can reduce complexity.

2 Six Disincentives to Adoption of Smart Environments

Although there are many barriers or disincentives to adoption of smart home/smart space technologies 6 key ones are:

2.1 Non-homogenous Product Technologies

The first problem is that homes usually have a wide variety of products from a variety of companies. Replacing them all with products from a single manufacturer is not economically practical in most cases. Also, unless you are only focusing on one general product type (e.g. home entertainment) a single manufacturer generally doesn't produce all of the products. Few companies for example sell washers, dryers, stove, lighting, heating, home entertainment and communication and computing products. And even fewer consumers purchase all of these from the same company.

2.2 Non- homogeneous Network and Connection Technologies

Within a home it is also common to find a wide range of technologies used for interconnection, communication and control including WiFi, Ethernet, Bluetooth, Firewire, USB, Powerline and IR. Trying to coordinate the functionality of products in the home with this wide a range of interconnection technologies presents a challenge.

2.3 Interoperability

In addition, different products may use different home control protocols. Such home networking protocols include, among others: Universal Plug and Play (UPnP) [6], CECED Home Appliances Interoperating Network (CHAIN) [7], HDMI Consumer Electronics Control channel (CEC) [8], HANA [9], and LonWorks [10]. Thus even products that may share a common network technology (directly or via gateway) may not work together. Users are reluctant to 'buy into' a particular technology or 'system' when they don't interoperate and it isn't clear what will win out in the end. Also, the investment to purchase a whole set of new products that are all compatible with one of the systems is a disincentive. Some of these systems do interoperate, but most consumers are unable to evaluate or configure such systems.

2.4 Investment

Replacing products with new 'smart' products is expensive. If networking is required additional expense is incurred. Often a network may exist but only in offices or select other rooms. If 'compatible' products are required in order to make a system work it can mean a sizeable investment that can be a barrier for many families.

2.5 Lack of Transition Path

Since users rarely can afford to purchase all new technologies at one time, there generally is a need to have some path for migrating from current technologies to 'smart' products. This process can take years. Yet the benefit of purchasing the first

smart technology needs to come with its purchase. Thus a model where new technologies can be intermixed with older technologies is important. At the same time the technologies must work across family members who may have widely differing technical skills and interests. Thus the technologies must also support users with high feature and technology skills and preferences down through users who eschew technology and use it only as necessary.

2.6 Compelling Reason

Because of barriers or disincentives such as those above, smart technologies are generally not adopted unless there is a compelling reason to introduce them. To date, it has been technophiles that have driven adoption. However that market is limited. To really take hold, there has to be a motivation that is compelling to a much larger portion of the mainstream market.

3 The NCS Approach to Incremental Smart Homes

To address these issues it is proposed to combine several new developments to create a naturally evolving intelligence in the home. The goal is not to create a smart home but rather to introduce intelligence into the home in a gradual and natural way that matches both economic reality and the sensibilities of the average household. This model is based on new developments in networking, task modeling, and interface, some of which are available today and some of which are just emerging.

Four new developments are key to this approach.

3.1 Pluggable User Interface Sockets

The first is a new set of 5 ANSI standards that have just been released called "*Protocol to Facilitate Operation of Information and Electronic Products through Remote and Alternative Interfaces and Intelligent Agents*" (also at the FDIS stage within ISO as ISO 24752). These standards provide a technology neutral mechanism for allowing products to be read, understood and controlled by other products. They also allow the introduction and use of intelligent artificial agents to control products or groups of products (such as an audio-video (AV) system).

The standards specify communications between a Target that a user wishes to access and operate, and a Universal Remote Console (URC) that presents the user with a remote user interface through which they can discover, select, access and operate the Target. The URC is software that is typically hosted on the user's physical device, but a distributed approach is also possible. URCs can include PDAs, cell phones, special watches and assistive technologies. Target devices can include home entertainment devices, clocks, thermostats, copiers, ATMs, and elevators as well as invisible targets like Web services.

The user interface socket is a low level description of a particular target product or service and specifies its operational input and output requirements. The socket describes the functionality and state of the target as a set of typed data and command elements. The data elements on the socket provide all of the data that are manipulated by or presented to a user (including all functions, data input, indicators, and displays).

Together with the commands, they provide access to the full functionality of the Target device or service in a non-modality specific form (e.g. it does not assume a particular type of user interface or display).

3.2 Universal Remote Consoles

The introduction of user interface sockets allows individuals to purchase home electronic devices individually over time (and from different manufacturers) and have them work with an intelligent controller they purchase (or have). Because the full functionality of the products is exposed via the user interface socket, it is easy for intelligent controllers to be able to directly access the full functionality of the products, rather than having to navigate all of the menus. The user interface socket also makes the devices "more machine understandable" as well.Work on universal remote controllers is currently being carried out at the University of Wisconsin, Georgia Tech, Marquette University, Carnegie Mellon University and University of Washington. These related efforts all focus on the development of a wide range of different user interfaces that could be applied to the same target devices to better match with the needs of their users.

3.3 Intelligent and Task Based Control

The existence of interface sockets also permits the introduction of controllers that span devices and that allow direct access to functionality of the devices without having to go through the standard menus to reach that function. The ability to control the functionality of multiple products simultaneously can for example allow an individual to issue a single command such as "play Masterpiece Theater" and have the controller change multiple settings on multiple products to cause the proper channel to appear be sent to the televisions which is turned on and changed from the DVD input to the cable box and the stereo to be changed from CD to television input. This type of multi-device task oriented control requires task modeling. An evolving standard on task model representation, CEA-2018, is currently being developed by the CEA working group R7 WG12 [11], and may help to provide this capability for future generations of devices in the digital home.

3.4 Universal Control Hub

To address the problem of non-homogeneous technologies and network technologies a "Universal Control Hub concept is being developed. The Universal Control Hub (UCH) is a gateway based architecture for implementing the Universal Remote Console (URC) framework [12] [13] in the digital home. It capitalizes on the features and functionality of the URC framework without requiring URC-compliant targets and controllers. The UCH architecture was originally proposed for UPnP based home networks [14], but is also applicable to any other networking platform and any combination of them.

In the UCH architecture, the control hub is the gateway between controllers and targets that would otherwise not be able to talk to each other. Since it handles most of the URC-related technologies internally, it can be used as a transition between legacy

products and products using other technologies. It can also house task based, cross product control technologies, and, by acting as a front end to products, add interface intelligence to existing products. Because the Hub can download interface sockets and other resources from the Internet, it can also adapt both to particular controller and to hardware configurations in the home.

4 NCS as a Platform for Evolving Intelligence in the Home

The combination of these technologies allow for the gradual and natural introduction of intelligence into the home, capitalizing on existing products and incorporating new target (controlled) products as well as new controllers as they evolve and/or can be afforded. The Hub would allow them to control their legacy products as well as products using different control architectures. The ability to control the household products via URC technology means that users can select and change their controller over time to meet their changing abilities. For example, if a person acquires a disability they could buy a new controller that accommodates their new limitations and provides them with the ability to continue to operate their household devices. And as people age, they can secure controllers that match their abilities and that will work with the appliances they already have. More importantly, elders can keep the same controllers that they know and are accustomed to – and use them with new products. No longer would they have to be confused and learn a new interface each time an old product (television, washer, thermostat, alarm) needed to be replaced.

As task based modeling and natural language advance, they could pick a natural language controller and have it operate the products in their environment for them. For example, a person could simply ask for television programs by name when they wanted to watch them. Or they could describe which programs they would like to have recorded and automatically have them programmed to record (all this without having to mess with finding the programs, figuring out how to ask the product to record the programs, locate the recorded programs later, etc.). Later, when they replace their clock radio, they could pick one up that was also URC or otherwise network compatible and they would find that they could now set their alarm clock by simply telling their controller (which could be, for example, just a function in their phone) what time they would like to have the alarm set to. At Christmas, they might be given a socket-enabled coffeepot, with the result being that anyone in the family can easily set it, because they can simply ask their controller to do it for them. None of the appliances would need to be intelligent beyond exposing their function and taking commands via their user interface socket.

Additional layers of intelligence and sensors can then be installed in the home in this incremental way. Using the same architecture, each of these sensors or agents could provide any central controlling unit (or each other) the ability to sense or know things. In addition, Internet services may provide supplemental descriptions of Targets that new intelligent controllers can harness to interact with Targets in a way that was not possible when the Target was purchased.

5 Conclusion

Much needs to happen before the more advanced, intelligent interfaces can come to fruition. However, the combination of these technologies can provide function today and also provide the framework for additional intelligent and easier to use interfaces to be incorporated into houses as they mature. Already simple task based controls and a variety of universal remote consoles are under development to address the needs of different users.

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