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In-home Smart Device Management Solutions

Introduction

As the adoption of Internet of Things accelerates and the number of products and standards in the space continues to rise, one of the challenges posed to homeowners is that of controlling their devices in a cohesive, simple manner. Since most brands use different software systems and sometimes even physical standards, interfacing with all the devices that may reside in one's home can be more complicated than it may initially appear. As Colin Angie, CEO of iRobot, says in an interview with The Verge [1]:

> The smart home ... hasn't quite lived up to expectations, I think. We've seen a great proliferation of different elements, ... but we've learned that these elements by themselves aren't necessarily enough to succeed. Very quickly, the amount of complexity you can manage in your home is overwhelmed by the number of connected devices, so we're at this awkward stage where we have many of the parts but we don't have a system that works."

To address these issues of interoperability, there already exist a number of consumer oriented products, open source software systems, and technical proposals. This technical review summarizes some of the key differentiating features and limitations of these solutions and examines the underlying technologies they utilize.

Commercial Applications of Smart Home Controllers

Given the breadth of physical and software standards that may be used to interface with smart home IoT devices, it is often the case that a single home will use multiple, if not many, devices with completely independent control systems. Though this does not prevent the homeowner from directly controlling the devices, it does hinder their ability to automate, synchronize, or otherwise integrate the separate systems. To allow for automation and cohesive control, a "smart hub" must be installed, either in the form of a dedicated physical device or as a server running some type of management software [2].

Physical Products

The consumer products that fill this role are generally physical devices, meant to connect with and provide a unified interface for all of the different IoT subsystems in a household. They may provide a direct interface, such as an integrated touch screen [3] or a voice assistant, but most commonly they will

offer a mobile app and web interface, enabling the user to manipulate the system from anywhere in their home. However, while this convenience is a strong selling point for most consumers, it comes at the cost of flexibility. These commercial products tend only to be compatible with established protocols offered by similarly commercial brands, limiting options for custom devices and software.

Software Solutions

The more flexible solution for implementing a smart home management system is to use a customizable software service running on a server. This enables the user to freely select the hardware and software, offering a much more extensive range of support and customization than a proprietary device. OpenHAB, for example, is an open source software home automation platform available for all standard server platforms and supporting hundreds of different services and devices [4]. In addition to standard consumer products and services, it can integrate with a large number of development tools including custom databases, cloud platforms, and web services. As an open, flexible platform, openHAB offers a substantial amount of value to users who need or want a personalized solution, but it lacks the approachability of an all-in-one system, since they must be manually installed, configured, and maintained. Though there exist a number of alternative software systems and proposals for flexible smart-device management [5], they all rely heavily on the user's ability to configure and integrate the system from scratch.

Technology Behind Home Automation Systems

There are a few different ways to implement a device manager such as the ones mentioned above, with one main differentiating factor. Although generally, all device management hubs should be networked to allow for remote configuration, they differ in how they can connect to the smart devices themselves. Some hubs connect exclusively to a traditional ethernet or wifi network and rely on separate bridges to interface with devices that use proprietary networking (often Zigbee or Z-Wave [6], [7]). In this case, the user must purchase and install a dedicated device to link to the smart devices to the traditional TCP/IP network, and the hub will connect to the bridge as an intermediary when issuing commands to the devices.

The second option for connecting to smart devices in the home is to do so directly. In this case, the hub will not only feature a traditional network interface, but also a direct interface for whichever alternative networking solutions it supports. This way, instead of needing a dedicated bridge, the hub itself is able to directly interface with smart devices that use nontraditional networking standards [3]. This adds

complexity and cost to the hub device, but simplifies the setup process for the user and reduces network complexity.

Software implementations inherently support communication using the IP based mode, as they will necessarily be connected to a standard network interface. However, they can also support direct connection over nontraditional networking so long as the user provides the appropriate hardware interface to communicate over the necessary protocols [8].

Building Blocks for Home Automation Systems

For a device to serve the purpose of a “smart device management system,” “home automation controller,” or “smart hub,” it must be able to connect to a variety of devices that use different physical standards, network protocols, or APIs, and enable the user to interact with them all in a streamlined environment. There are a few specific components that are required .

Firstly, a physical computing device is needed. This will process all of the data going into and out of the devices and will run any software necessary to interface with the devices. It will need to be available at all times; device failure will result in the user losing control over their devices. This device can be an embedded device preloaded with all necessary software or a more traditional server that the user configures for themselves.

Secondly, the device will need one or more network interfaces. Ideally, it will have one traditional interface to connect to the user’s TCP/IP network and secondary interfaces to allow direct connection over other non-IP network standards.

Thirdly, the device needs software to connect with its compatible products. Each product may use a different API, but they must all be presented to the user in a cohesive package. This compatibility may be built into the base software or it can be provided as optional add-ons [8]. A more thorough analysis of the

Finally, the device must run some sort of control engine and user interface. The software on the hub must be able to accept user inputs and commands as well as provide them with relevant information from their devices. This interface must be implemented in software and generally includes a remote management interface.

References

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