

Smart Home Automation

What is a “Smart Home?” While this can mean many things to different people, I think of it as one that uses a combination of sensors and controls, which are integrated through communications, so that they can “talk” to each other, and can send notifications and receive remote commands.

Earlier systems that you might have used to make your home “smarter” include lamp timers that you might have used to turn lights on and off when on vacation, and outdoor lights with a light sensor or a motion sensor. Aren’t these things “smart?” Not really, since your motion sensor lights can’t trigger other actions, and your light timer can’t be adjusted remotely...

A Day in the Life in a Smart Home

- Fifteen minutes after sunrise, the outside porch lights turn off (according to the sunrise time each day)
- The smart thermostat changes the comfort settings to set the temperature before we wake up.
- When I come out to the kitchen, I tell Alexa “Turn on the Kitchen Lights”
- After breakfast, when I leave the house for the office, I tell Alexa to “Turn everything off” which turns off all of the lights, etc.
- As I leave through the front door, I lock using the keypad. I’m not even carrying a key. The door has a sensor that would turn on the porch lights if it were dark out. The smart lock reports that the lock was opened, then locked again to the smart home hub. It could send an alert if the door remained opened or unlocked. It can also be used to trigger actions in a home security system.
- The smart thermostat senses that the house is empty, and sets back the temperature to save energy.
- During the afternoon, I receive a package delivery. My NetGear Arlo camera on the front porch detects motion, and records the event, and sends me a notification. I can use the app on my smart phone or tablet to watch a live video/audio feed, communicate with the delivery driver using the mic and speaker built into the camera, or replay the video remotely.
- Thirty minutes before sunset, the outside front porch lights turn on (according to the sunset time each day) so the lights are already on when I arrive home.
- After working all day, when I return home, the smart thermostat senses that I have returned home, and resumes the preset schedule for the temperature.
- When I open the door to the garage to get something for dinner from the freezer, the Garage Light turns on automatically.
- When I close the freezer door, it doesn’t shut all of the way... The door sensor alerts me by text message after five minutes, so that I can get it shut tightly.
- Ten minutes after I came in from the garage, a timer turns off the light.
- I tell Alexa to “dim” the kitchen lights to 100% while I’m cooking, and ask her to “play some jazz music” as well. I also ask Alexa to set a timer for twenty minutes.

- I have Alexa turn off the kitchen lights, and dim the dining room lights to 30% when I'm ready to sit down to dinner.
- I have used up a couple of items from the fridge and the pantry, so I ask Alexa to add margarine and macaroni to my shopping list. I can ask Alexa what is on my shopping list any time, and she will tell me what is on the list. I can also see it using the "Todoist" app on my smart phone when I'm at the grocery store, and check items off as I pick them up.
- After dinner, I go downstairs to my office in the basement, carrying my backpack, iPad, and a cup of coffee, so my hands are full. The motion detector in the stairway turns on the lights in the stairwell. As I turn the corner into the office, another motion detector turns on the lights in my office. The smart thermostat sensor in my office detects that the room is occupied, and uses that sensor to control the HVAC.
- After ten minutes of inactivity, the lights in the stairway turn off automatically.
- Later in the evening, I leave my office and go back upstairs. After thirty minutes of inactivity in my office, the lights turn off automatically, as well as the lights in the stairway.
- When I sit down on the couch in the living room, the smart thermostat sensor detects that room is occupied, and uses that sensor to control the HVAC.
- I turn on the TV, but realize that I left the remote control for the satellite dish on the kitchen table... I just ask Alexa to "Turn on channel 9" to switch channels.
- I hear the dogs barking outside, and open the back door. The patio light comes on automatically, with a 30-minute timer to turn it off after I close the door. If I had turned the lights on manually using the switch, the lights would stay on, instead of using the timer.
- At 10pm, the lights in the kitchen dim to 25%, so that it's not so bright.
- After the news, I get ready for bed. Before getting into bed, I tell Alexa to "Turn Everything Off" to make sure that I got all of the lights (except the porch lights) and ceiling fans turned off.
- The smart thermostat "sets back" the temperature to save energy.

Why Automate Your Smart Home?

- Convenience/Luxury
- Safety
- Security
- Energy Efficiency

There are many benefits to smart home automation, and lots of different reason why you might decide to make your home smarter.

For many people it is a convenience to have lights turn on at night and off in the morning, or to have lights in a closet turn on and off automatically by a motion sensor. Others might choose to automate exactly the same things, but because of safety or security, or because it helps to reduce energy consumption. Because of the varying reasons to automate, you might get some unexpected side benefits.

Concerns

- Privacy
- Security
- Interoperability with other devices
- stand-alone vs. hub device vs. interface vs. web service

Protecting your personal privacy is becoming more of a concern in our interconnected world. Can using “smart home” devices be used to track a person’s activities. Probably at some level, but it’s likely no more than cell phone usage.

One of the primary concerns that many people express is security. Can these smart home devices that are internet connected be hacked and controlled remotely, or share private information? Are our smartphone cameras and microphones watching and listening all of the time? Is your smart home assistant/smart speaker like Amazon Echo or Google Home listening to your conversations?

Like our computers and home WiFi networks, taking care when setting up smart home devices can mitigate many of the security vulnerabilities. Most devices have to be paired with a hub, much like pairing devices using Bluetooth. Once they are paired with a hub, other devices should not be able to communicate with them. Many of the home automation protocols like Z-Wave support encrypted communication, to help prevent hijacking or monitoring. Just like with home network devices, it is important to apply software and firmware updates, and change the default passwords. Some devices are able to install software updates “over the air” through the internet, or through the hub to which they are connected.

Interoperability is an issue with home automation devices, as there are a variety of competing standards. Most devices comply with a standard, but it doesn’t guarantee compatibility with every product.

Apple’s HomeKit was designed to have better security, and easier setup, but hasn’t been widely adopted by many manufacturers. Because of this, there isn’t a broad selection of supported devices, and they tend to be more expensive than competing products. Z-wave Plus also supports encryption, especially useful for locks.

Another concern is whether your smart home devices can operate autonomously, or if they require a connection to an internet service to operate. Samsung’s SmartThings Hub or Schlage’s Nexia hub do require an internet service to function. Samsung has had a couple of outages in the past year, where customer’s smart home devices were inoperable during the outage. Many of these services require a monthly or annual subscription to operate, which must be factored into the cost of your home automation. Other devices only require the connection to the hub which controls them, so they can operate standalone, and will continue to operate without an internet connection, except for remote control or notifications.

What Can Be Automated?

- Schedules (timers)
- Remote Control
- photovoltaic sensor/rain sensor/motion detector
- Interactive (sensor event/trigger-activated)
- Integrated (monitoring/notifications)
- Geofencing/presence detection

As I mentioned earlier, some of the early methods of automating included scheduled timers, photovoltaic light sensors, or motion detectors. These sensors were usually dedicated for a single purpose, though, which limited their abilities. Modern sensors can communicate with a hub or controller through a radio network like Bluetooth, WiFi, or one of several specialized low power automation networks and protocols like Zigbee or Z-Wave. The controller can use these sensor signals to trigger a wide range of events, from turning lights on or off, sounding an alarm or sending an email or text notification.

To be truly “smart” the sensors and devices need to be able to communicate interactively, sending notifications and receiving commands from a hub or controller, or through a remote control device like a cell phone.

Another new capability is found by being able to detect the presence in the home, either through passive infrared motion detectors, or through “geofencing.” Geofencing typically uses a location service like the GPS in your smart phone to determine when you are home or away. Other methods include watching for devices like a smartphone to connect to your home WiFi network, or perhaps detect a signal using Bluetooth. Any of these methods can be used to trigger different behaviors based on whether you are home or away, or are arriving at home, or leaving the house.

Types of Devices

- Outlets (or modules)
- Lighting (smart bulbs vs. switches vs. modules)
- Home Entertainment (TV, audio)
- Fan Controls
- Window Coverings (blinds/curtains/frosted glass film)
- Thermostats
- Door Locks/Garage Door
- Cameras/Security Systems
- Sprinkler Systems
- Voice Assistants
- Sensors (water, motion, sound, shock, light, temp, humidity, open/close/contact)

There are an infinite variety of smart home devices available on the market today, supporting many different networks or protocols.

One of the most common devices to start with is a lamp module. This small box has a plug and an outlet, and is plugged into a standard electrical outlet. You can plug many types of devices into the outlet in order to control an existing appliance or lamp. Some are simple on/off switches, while others offer the ability to dim the light. Some support the higher current draw of an appliance like a fan, but are typically only an on/off switch. These lamp modules do not require permanent installation, so they are ideal for renters, or to experiment before investing in other devices that require a more permanent installation.

Another common smart device is an LED light bulb which has a control module built into the base. These lights can be controlled remotely when connected to a compatible controller (more on that later!). Since LED bulbs are expected to last for up to 20,000 hours, they can provide many years of service. The LED is also a lower energy usage than conventional incandescent light bulbs, and generates less heat as well. Two additional benefits of LED bulbs are that many are available in different “color temperatures” to produce light which is “warm” like an incandescent, or “cool” like a florescent light. While they can be a bit more expensive, some bulbs let you adjust the color temperature by including several white LEDs. Others contain four or five color LEDs, and can change colors as well, for special lighting effects. Many of these color-changing LED bulbs can produce up to 16.7 million color shades. These bulbs are offered in several shapes and sizes, from candelabra bulbs, A19 “Edison” base like a typical bulb, or BR30 reflector bulbs for can lights.

While less common, there are also lamp modules that have a lamp base and socket, which can be inserted into an existing light, with any type of bulb inserted into the socket. While these might sound more flexible, they are often bulky, and don’t fit easily into many lamps or light fixtures, so the integrated LED lights with built-in control modules are probably more convenient.

One of the drawbacks to many of these lighting options is that the existing on/off switch which currently controls the power must be left in the ON position all of the time, so that the control module has power to operate. If the wall switch (or switch in the lamp) is turned off, it will prevent any automated control, as the device doesn’t receive any electrical power. Many of the automation systems like Phillips Hue offer control switches which can be wall mounted near existing switches. Many people will install a clear plastic switch cover over their existing switches to prevent them from inadvertently being switched off. Some of these covers are open on the side to allow manual operation, while preventing accidental usage.

Rather than replacing individual light bulb, there are also smart switches that can be installed by replacing an existing wall-mounted switch. This option provides a number of benefits. The smart switch can control one or more conventional lights in existing fixtures, which can be less costly and less complicated than replacing multiple light bulbs. The smart switch can also be operated manually like a conventional switch, so you have the choice of automatic or manual operation. Because the control module in the switch is always receiving power, it can operate whether the smart switch is turned ON or OFF.

Another option is an LED lighting strip. These flexible strips can be attached with adhesives or fasteners, and can provide either white light or can be color-changing LEDs. Many people find that mounting a light strip to the back of a flat panel TV can improve the contrast for easier viewing. Another common use is to place the light strip under kitchen cabinets, or under a bed frame to provide a night light for safety.

Controlling a ceiling fan with a smart controller is also possible with a fan controller. Most support multiple speeds, so the fan can be left set on its highest speed, but turned up or down through the fan controller like a dimmer switch.

Some other types of smart home devices include smart thermostats. These devices control your heating and air conditioning system like a conventional thermostat, but can be remotely controlled by a smart phone when in the house, or when away, by connecting through a web service or application. They can also be integrated with smart home systems to detect whether you are home or away, and change the temperature settings to conserve energy usage. Some smart thermostats can utilize weather forecast information from web services to predictively control the settings, proactively changing the heating or cooling based on the outside temperature. They can also report statistics to show runtime, energy usage, etc.

While the hub or controller provides the “brains” for your smart home, it utilizes a variety of sensors to act as it’s “senses.” The most basic is the door or window switch used in home security systems for many years. These are typically battery powered, and low energy so that the battery can last for many months, up to a year. The door sensor can be mounted to door frame, typically with a magnet attached to the door. When the magnet is aligned with the sensor, it “knows” that the door is closed. When the magnet is moved away, it senses that the door is open. While these sensors are typically used to provide door (or window) entry or exit monitoring for security, in a smart home they can also trigger other actions such as turning on lights.

Another common and versatile sensor is the passive infrared (PIR) motion detector. These small devices are again like the motion detectors commonly found in home security sensors, and detect movement or activity in a space. These sensors can be used to trigger devices like lights, or to detect the presence of occupants in the room or area, to set multiple actions, including heating and cooling or fan controls, as well as lights. Many of the motion detectors actually contain multiple sensors, including a photovoltaic light sensor, as well as temperature, humidity, and sometimes sound or vibration. These multi-sensors are one physical module, but may appear as multiple, individual sensors to your home automation system.

Major Manufacturers

- Aeotec/Aeon Labs (Z-wave)
- Belkin and TP-Link (WiFi)
- Ecobee (WiFi and HomeKit)
- GE (Zigbee, Z-wave and Bluetooth LE)
- Honeywell and Trane (Z-wave)
- Logitech Harmony
- Cooper, Leviton and Lutron
- Nest (BlueTooth, WiFi and Zigbee)
- Phillips/Signify and Sylvania (Zigbee)
- Kwikset and Yale (Zigbee)
- Schlage (Z-Wave and HomeKit)
- TP-Link (WiFi)

There is a wide variety of manufacturers producing smart home devices today, far too many to list them all!

Protocols/Standards

- X-10 (Power Line Signaling)
- WiFi (2.4GHz and 5GHz)
- Bluetooth LE (2.4GHz)
- Insteon (Newer X-10 compatible mesh network)
- Zigbee (802.15.4 @ 2.4GHz)
- Z-Wave (800-900MHz)
- Apple HomeKit (WiFi and BlueTooth)
- Thread Group

One of the early home automation protocols was call “X-10.” It was convenient to setup, as it sent signals over the power lines through the house, so it didn’t require any special wiring. Devices could communicate with each through the electrical wires that provided power, as well as control modules that provided scheduling and remote control. Unfortunately, communicating over power lines doesn’t work very well, as there is a lot of interference, etc. This caused X-10 devices to not be very reliable, often requiring sending signals many times before getting a response or action to occur.

Using WiFi is also a convenient method to use for home automation, as most of us already have a WiFi network setup at home, and it has a range of up to 300 feet, large enough for most homes. The drawback to using WiFi is that it requires a fair amount of power at the device, so it only works well for modules that are plugged into electrical power all of the time, like lights and outlet modules. It requires too much power to operate easily off of batteries, so it isn’t practical for many types of sensors.

BlueTooth, and it low power version, BlueTooth LE, also sound like a convenient method, but many of these devices do not have much range, so they only work well for devices that are fairly close to the control hub, usually within about 30 feet.

Insteon is a more modern take on the X-10 protocol, but it combines the power line signaling with a radio “mesh network” where each device can act as a repeater to rebroadcast messages to neighboring devices, either through radio or power line. This allows Insteon devices to have better range and reliability than X-10, while maintaining backwards compatibility with older devices. There is a wide range of Insteon devices available.

There are several modern protocols designed primarily for building- or home-automation or security. One of these is Zigbee, which is the protocol used by Signify/Phillips Hue lighting and control devices. It is low-power, so it can operate on batteries for longer periods (several months). Zigbee is also used in home security systems, including ComCast Home Security, and other providers like ADT. ZigBee uses the 2.4GHz radio spectrum like WiFi and many cordless phones.

Z-Wave is another common home automation protocol, which creates a hybrid radio (908MHz) and power line “mesh network” like Insteon, so each device can repeat messages to/from other nearby devices, extending the range and improving reliability. Z-Wave devices learn how to best route messages to nearby devices. Z-Wave can also support encryption for devices like locks.

Apple’s HomeKit is a late-comer to the smart home party, and hasn’t been as widely supported as many of the other protocols. Introduced with iOS8, the “Home” app does integrate with Siri for voice controls. There are a few manufacturers supporting HomeKit with a variety of devices, but they originally had to be licensed/certified through the “MFi” program like iPhone accessories. Apple also requires encryption, so the devices tend to be more expensive. At launch, this required certain hardware, but is now implemented in software. HomeKit can connect to some other smart home bridges like Philips Hue, WeMo bridge or Lutron Caseta Smart Bridge, to allow integration through Siri and HomeKit. For remote access from outside your home, you need to have an AppleTV that is fourth-generation or later with tvOS 7 or later, a HomePod, or an iPad. For iPad to act as a home hub, it must remain in your home, powered, and connected to your home Wi-Fi network. Adding devices to HomeKit is fairly easy, though, as you might expect from Apple. Using the Home app on an iOS device, you can scan the barcode of a compatible device to add it. You can give it a name and set which room it is located. HomeKit can organize devices by rooms and zones, and can create “scenes” using memorized settings. The Home app can create schedules, trigger based on events, or on who is at home. Since HomeKit primarily uses either Bluetooth or WiFi to communicate, it doesn’t have as many options for low-power battery devices. There are more devices announced or “coming soon” so there are more options, and the prices are becoming more competitive with other offerings.

Thread is an open source project sponsored by Google. It uses IPv6 protocol to allow direct connection to the internet, which might be convenient but could increase security risks. Apple has recently joined the Thread group, so it might be looking to extend HomeKit beyond Bluetooth and WiFi.

Hubs

- Samsung SmartThings (Z-wave and Zigbee)
- Lowe's Iris (Z-wave and Zigbee)
- Belkin WeMo (WiFi)
- Apple HomeKit (BlueTooth and WiFi)
- Phillips Hue (Zigbee)
- Indigo (X-10 and Z-wave interfaces)
- Schlage Nexia (Z-wave)
- Eve (formerly ElGato) (HomeKit)
- Lutron Caséta

A hub, as the name implies, acts at the central control point for your devices. The hub usually has interfaces for one or more of the protocols, and an interface to allow the user to manage devices, set schedules and triggers, etc. Sometimes it uses an embedded web server, an application on a smart phone or tablet, or through a website. Some devices that use BlueTooth or WiFi only connect via an application on your smart phone, so they don't require a separate hub, using only your WiFi network.

The SmartThings hub started out as a "kickstarter" project, but was later acquired by Samsung. One of the advantages of SmartThings is that the hub supports both Zigbee and Z-Wave, so it supports a wide range of devices.

The Lowe's Iris hub also supports both Z-Wave and Zigbee, so it also supports a wide range of devices. The drawback to Iris is that it requires a subscription to a web service for advanced features.

Software

In addition to dedicated hubs, a home automation system can also be operated using a computer, an interface of some sort, with specialized software. In my case, I am using an older Mac mini with a software package called "Indigo" from <http://www.indigodomo.com> which can be purchased for \$249.95, and is now offers an annual update subscription. Indigo has built-in support for many devices, and also supports a "plug-in" architecture to allow users to add additional devices. Indigo provides the capabilities to define and control devices, set schedules, create event triggers, and can create action groups to perform multiple actions in response to a single event. Indigo supports a variety of interfaces, particularly the Aeotec Z-Wave USB Stick, and several Insteon USB interfaces. It incorporates both a "server" portion which can be left running all of the time, as well as a "client" application which can be used to manage the devices, schedules, etc. There is also an iOS application for the iPhone or iPad, which allows basic control over devices, which can be used from anywhere in conjunction with a subscription service.

Services

- IFTTT (Free)
- Iris by Lowe's (Free/\$9.99/\$14.95/month)
- Schlage Nexia (Free/\$4.99/\$9.99/month)
- Samsung SmartThings

One thing that you must be aware of is that many home automation systems rely on cloud/web-based services to operate, many of which require a paid subscription.

The free web service "If This Then That" (IFTTT) <https://ifttt.com> can be used to create triggers and actions for connected applications and devices. At least, in theory... Despite multiple attempts, I have been unable to actually create an account, so I can't say much more about it.

Iris by Lowe's can connect to either Zigbee or Z-wave devices, but uses a web service for setup and automation. The "Basic" level is free, but somewhat limited. The "Premium" level is \$9.99/month, or \$14.95 for security monitoring.

Similarly, the Nexia hub by the parent company of Schlage, Ingersoll-Rand, requires a web service to operate. The "Basic" level is free, but limited. The "Monitoring" level can be used with unlimited number of sensors, but only four lighting devices. To use more than four lighting devices, you have to pay for the \$9.99/month "Complete" plan.

Samsung's SmartThings hub also requires a connection to a web-based service to operate. The SmartThings service is free, but they have recently suffered several outages that prevented the devices from operating, including an issue in March that lasted over a day.

Security Cameras

- Arlo
- Ring
- Nest

Video surveillance is another popular feature for home security systems. There are a number of types of these systems, so I'll mention just a few.

Arlo is a subsidiary of networking gear company NetGear. Their Arlo cameras offer battery powered WiFi cameras with HD video capability, and include mic and speakers as well. They offer a free service to access recordings from a smart phone app or the web for up to seven days, and additional offerings are available on a subscription basis.

The Ring doorbell camera is a popular choice for monitoring who is coming to your door. Ring offers many other cameras and security devices as well.

Nest also offers a variety of indoor and outdoor cameras in addition to their lineup of smart thermostats, including a doorbell camera.

While these devices may not integrate directly into your other smart home devices, they are able to send alerts and notifications through their smart phone applications. They can provide both security and convenience to your smart home setup. Remember to look at the cost of any subscription services that you might need, in addition to the cost of the hardware.

Video Example

This video shows the smart home setup done by a guy who is a professional lighting installer, so it's probably not a typical setup, but it demonstrates what can be done by integrating a few "off the shelf" commercial products together.

<http://www.youtube.com/watch?v=0t0YTi2JOuk&sns=em>

Getting Started

If you are interested in setting up smart home devices in your house, start by thinking through the types of things you would like to have automated. For me, it was driven by eliminating inconvenience! Having to go down to the basement or out to the garage to turn off lights at night was a bother, so they were some of the first things that I automated. I started with a lamp module and a light to experiment, then installed my first Z-Wave switches to control the outside lights with a smart schedule that determines the sunrise and sunset times each day as the trigger.

It's important to think big, but start small. Make sure that you have your final solution in mind when you start, and make sure that the devices you purchase will be compatible (or complimentary) with your system as it grows. Don't try to automate everything at once. Start with one or two devices to "get your feet wet" before making a big investment. Try to tackle only one area or room at a time, so that it doesn't become overwhelming.

Start with the core first, by deciding on a protocol, hub or voice assistant that you like, and build up from there. You might start with an Amazon Alexa or Google Home, and add a Philips Hue lighting starter kit. Apple's HomeKit is easy to setup, if it offers the devices that you need.

Make sure to consider how things will work without using the smart home system. Using lamp modules or smart bulbs with circuits that get switched on and off at the wall won't work automatically unless the switches are left on all of the time. You also aren't going to want to use your smart phone to turn your lights on and off all of the time. I mostly used Z-Wave smart switches that still operate "normally" as a wall switch or dimmer, but can also be controlled remotely. You may also need to consider limitations on installing devices if you are renting, as you probably wouldn't be allowed to replace switches or fixtures.