Executive Summary

Simply put, there are too many choices for today’s low-end mainstream\(^1\) and DIY\(^2\) consumer when it comes to connecting the new breed of Home Automation (HA) equipment. With the plethora of thermostats, lights, locks and consumer friendly HA devices hitting the market from Nest, Philips, Belkin, Honeywell, Insteon, Schlage and others, it has become increasingly difficult for consumers who desire to install their own systems or work with a low-end installer, to decide which technologies make logical sense to control their entire home. Apple and Google have just begun to approach these markets, and with no clear technology leader, average (and not-so average) consumers are left to guess which direction to spend their money.

Smart manufacturers realize the real reasons for the current state of the low-end mainstream and DIY market are:

- The controller of choice for both these markets is not something new, and it’s already in consumers’ hands.—A smartphone or tablet.
- Wi-Fi is and will be the main wireless technology in the home for connectivity to the internet (WAN). Consumers already have this technology in their home, so adding home automation functions via Wi-Fi should be easier and cheaper – but may not be, yet.
- Current home automation products are presented more as stand-alone devices than systems. Locks, security systems, lights, etc. all use a wide variety of connectivity technologies (Wi-Fi, Bluetooth, Z-Wave, ZigBee, Insteon). There is no single software interface to control these systems other than adding an integrated controller to the system (Revov, Nexia, SmartThings).
- The low-end mainstream market is extremely price sensitive and most likely requires an installer, but with the stipulation that the end user can, in the future, personally add and grow the system, they also want an integrated software interface to control the entire solution.
- The DIY market is dominated by adding (likely retrofitting) one or two automation items to the home at a time, rather than installation of entire systems in one shot.
- As with many things, it’s the software that the consumer uses every day that really matters.

These points reinforce the presumptions that first, the smart home connectivity market is going to be fractured for years to come, and second, over the long haul, manufacturers and consumers will most likely bet on the current incumbent technologies that dominate the end

\(^1\) Low-end mainstream is defined as consumers that use an installer to purchase and install systems. Low-end is defined as the $5k installation range

\(^2\) DIY is defined as consumers that purchase systems or endpoints through retail channels and integrate the systems themselves
controllers (i.e. smartphones and tablets), Wi-Fi and Bluetooth.

**Lay of the land**

The home automation market was, and continues to be dominated by installers. Mainstream consumers looking for home monitoring and security applications hired a vendor who installed whatever lines they carried. These systems were wired into the house, and connected by a POTS line to the monitoring station. Wired technology was secure, had no latency, high bandwidth and low power making it an easy choice. The downside is the installation. Unless you were building a new house, wires have to be run in the walls, which can be quite difficult and require expensive (and professional) installation.

The history of consumer direct involvement [i.e. DIYers} in home automation goes back to X10 systems\(^3\), originally conceived of in 1975, with the first real controllers delivered including light switches, thermostats and other devices delivered to the market in 1978. In 1989 X10 delivered the first wireless security system to hit the market – and people still chose to use wired systems.

The introduction of Wi-Fi changed the low-end mainstream and DIY market radically. Initially, the reliability and performance of Wi-Fi made it a non-starter for security systems. Wi-Fi was easily hacked, if people even remembered to configure the security. Full house monitoring could be difficult over larger homes because of Wi-Fi coverage issues. In addition, Wi-Fi can have interference and bandwidth issues that don’t provide true always-on connectivity necessary for security applications.

Today Wi-Fi has matured, and is widely available in the homes looking for home automation systems. The advantages to wireless installations are great, especially for DIYers. Lower cost, no wires to run, no holes in walls, fundamentally you install devices, connect them to your network and you are good to go.

The second introduction that radically changed the home automation market was the advent of cellular technology and widespread acceptance of smartphones. Cellular technology added another way to connect to the monitoring station that didn’t require a wire. As cost have been driven down, you can now find monitoring solutions from companies such as Alarm.com for as little as $15 USD per month. Smartphone users, certainly the majority of the segment seeking home automation solutions, are able to monitor and interact with their systems from wherever they are and whenever they choose.

Today, PCs and smartphones have become common place, and most consumers are no longer afraid to use technology. As a result, today’s HA environment is brimming with home users installing their own home devices and systems that control not only security, but a host of new and exciting options that were previously only available to the luxury category of installations.

The list of items to tweak and play with is seemingly endless and continues to grow. Typically home automation systems have the ability to integrate and perform the following general functions:

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\(^3\)The History of X10 by Edward B. Driscoll, Jr. (information provided by Jeff Deneholtz of X10)
• Home Control – this includes control of lighting, climate, window coverings, appliances, pools and spas, irrigation, and access.
• Entertainment Control – this includes home theater or multi-room audio systems.
• Energy Management Systems – this includes both the monitoring and management of energy systems such as HVAC
• Home Monitoring and Security: this includes both standalone systems that are monitored only by the home owner, as well as the traditional alarm monitoring companies
• Healthcare and Eldercare Monitoring – this is an early-stage market that is not yet widely deployed. We do expect large growth in this emerging market within the next 10 years.

From a consumer’s perspective, there are currently a wide variety of commercially available and easily installable devices to allow them to control systems with all of these functions. The current craze spans both old “revered” companies such as GE and Honeywell to new start-ups such as SmartThings, Lockitron and August.

Here is a quick overview of the hottest new HA devices and companies:

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All of these new systems are able to simply and easily be purchased and installed by the consumer, without the need to hire a professional installer. The other commonality between all of these systems is they use wireless technology to connect to networks, and the consumer can control these devices from their smartphone or tablet. Some of these devices may be controlled through a hub (like the Revolv, SmartThings or Nexia), some can be controlled directly (Lockitron, Nest), and some both (Philips Hue, Belkin WeMo).

The big challenge for the consumer is when they try to integrate a full range of these end-point devices. Some connect via Wi-Fi, some Bluetooth Smart, some Z-Wave, some ZigBee, and the list goes on. How does the low-end mainstream and DIY consumer choose, and which technologies should manufacturers implement? Let’s first overview each of these technologies.

### Wi-Fi

Wi-Fi is ubiquitous in today’s home, so it should come as no surprise that a wide range of current home automation devices are already compatible with this standard. Originally developed by the IEEE (802.11), Wi-Fi was designed to allow an electronic device to exchange data or connect to the internet using 2.4 GHz and 5 GHz radios. Most people know of Wi-Fi as their access from their PC/Laptop/Tablet to the World Wide Web (WWW).

The advantages to using Wi-Fi are many. First is its ubiquity. Most people have access and many, if not all, consumers considering home automation systems have it already installed. There’s no need to add a hub or access point to connect your devices, and your controller (smartphone/tablet) is already connected. Wi-Fi was designed to handle large amounts of data traffic, so bandwidth to control your home devices is not an issue. In addition, the range of Wi-Fi does not tend to be an issue when connecting a home. A stock antennae can provide 35m indoors and over 100m outside. Finally, from a security standpoint, Wi-Fi implements Wi-Fi Protected Access (WPA and WPA2) encryption, which has been shown to provide reasonable security for home users when actually implemented.

Wi-Fi’s key drawbacks include interference and bandwidth issues. Wi-Fi connection speeds can be lowered or even disrupted by having other Wi-Fi devices in the same general area. Most 2.4 GHz 802.11a/b/g access-points default to the same channel on initial startup, contributing to congestion on certain channels, specifically channels 6 and 11. City and apartment dwellers...
have to deal with large numbers of access points all within the same location. In addition, devices on the neighboring channel can prevent access and interfere with other devices’ use of other access points, caused by overlapping channels in the 802.11a/b/g spectrum.

Additionally, other devices use the 2.4 GHz band. Bluetooth and ZigBee devices, cordless phones, microwave ovens, and even baby monitors all can cause significant additional interference. If your house is already fully connected with HDTVs, laptops, tablets, phones and game consoles, all those devices are competing for the same bandwidth, and you can expect slower response times. The good news is that most home automation endpoints are not bandwidth hogs, and this response time may not matter. Regarding battery operated applications, Wi-Fi consumes much more power than other technologies so it is not ideal for devices such as locks. Finally, as with all wireless technologies Wi-Fi has latency and potential drop-outs making it a reasonable choice for audio, but not for true audiofiles.

Bluetooth Smart (Low Energy)

Bluetooth Smart (the marketing brand for Bluetooth Low Energy or LE) is a power efficient version of Bluetooth wireless technology so prevalent in today’s smartphones, primarily for headset use. The technology was designed to build on the installed Bluetooth base, but reduce power and cost for wearable and battery operated applications. Bluetooth Smart retains the same range as Bluetooth Classic, over 100m (your mileage may vary!). The Bluetooth Special Interest Group (SIG) added numerous profiles for healthcare, sports and fitness and proximity, and it has planned profiles for HA systems in the future. Bluetooth Smart technology operates in the same spectrum range (the crowded 2.400 GHz-2.4835 GHz ISM band) as Classic Bluetooth technology, but uses a different set of channels.

Bluetooth’s energy profile and installed base has made it an early favorite for connections in the smart home. ABI Research forecasts Bluetooth Smart technology will experience the highest growth in the smart home market, reaching over 133 million units shipped by 2018. The combination of energy efficiency and the ability to work with existing smartphones/tables and applications consumers already own has made it easy for developers and OEMs to create solutions that can immediately be added to existing systems. Apple, Android and Microsoft all provide native support for Bluetooth.

The downside of Bluetooth is the initial connection or pairing, which consumers have been struggling with for years. Newer versions of Bluetooth have made this pairing process much easier and more, but consumers have a long memory. In addition, Bluetooth uses data compression making it a less than stellar choice for audio applications. However over time Bluetooth has improved its audio profiles and quality. If you want the best possible audio quality from a Bluetooth device, look for headphones and speakers that support **aptX**, an audio codec designed for **CD-quality audio transfer over Bluetooth**. Alternatively, look for support for **A2DP**.

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4 Analysts Project Bluetooth® Smart Technology to Lead Home Automation Market, Bluetooth press release
or Advanced Audio Distribution Profile, which also requires compatible devices, but is designed for sending stereo audio over Bluetooth to speakers, car stereos, and headphones.

**Z-Wave**

Z-Wave is a wireless home automation protocol that is relatively new, but has grown significantly over the last few years. Z-Wave uses extremely low amounts of power and runs on a mesh network. The group behind it, the Z-Wave Alliance, now boasts over 1,000 different compatible devices, giving consumers a wide range of options when it comes to automating their homes.

Z-Wave communicates in a sub-gigahertz frequency range, around 900MHZ, competing with a few cordless phones and consumer devices, but steering clear of Wi-Fi, Bluetooth and other systems that operate in the crowded 2.4GHz band. The protocol is optimized for reliable, low-latency communications, unlike Wi-Fi, which is generally designed for high-bandwidth data applications.

Z-Wave utilizes a mesh network architecture, and can begin with a single controllable device and a controller. Additional devices can be added at any time, as can multiple controllers, including traditional hand-held, key-fob, wall-switch controllers, along with PC applications designed for management and control of a Z-Wave network. Using multiple controllers allows Z-wave to extend to long ranges to cover homes both large and small.

The downside of Z-Wave is, of course, it is not in your smartphone or tablet, and it is not in your home – unless you specifically buy a controller to put it there.

**Zigbee**

ZigBee has been in battle for a place in the wireless community for years. Competing against Bluetooth and Z-wave in low data rate applications for the home, and Wi-Fi in infrastructure applications, ZigBee has had to accept small wins where they can get them.

ZigBee is a low-cost, low-power, wireless mesh network developed by the IEEE (802.15.4). ZigBee operates in the industrial, scientific and medical (ISM) radio bands: 868 MHz in Europe, 915 MHz in the USA and Australia and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 kilobits/second in the 868 MHz frequency band to 250 kilobits/second in the 2.4 GHz frequency band. The low bandwidth and power combined with low cost should have made ZigBee the go-to protocol technology for home automation systems. It hasn't happened.
ZigBee has been plagued by inter-operability problems. The ZigBee standard defines not only the wireless transport mechanism, but also a software layer (similar to Bluetooth) that provides profiles that can and have interfered with different versions of other ZigBee profiles. This means that unlike Wi-Fi, two devices that have ZigBee chips might not inter-operate. The ZigBee Alliance is working to mitigate this situation, but again this has caused manufacturers to think twice about using ZigBee as their HA standard of choice.

New to ZigBee is the movement to create a connection to the internet using low-power, low cost ZigBee radios. 6LoWPAN is an acronym for IPv6 over Low power Wireless Personal Area Network. The idea is to leverage the ZigBee radio send and receive IPv6 packets to enable new applications, such as smart meters, to send data back to vendors via the internet backbone. This has broad potential for use in the home, connecting ZigBee devices directly to the network, rather than the consumer needing to add another controller box to their home network.

**Insteon**

Insteon is a home automation networking technology designed by Smartlabs, Inc. to bridge the gap between powerline-based and wireless protocols, and it uses both. Insteon provides a wide range of motion sensors, lights, light switches and other devices that can be connected through a dual mesh network, using either or both power lines and RF communications. It is also compatible with x10 devices.

Insteon is a proprietary technology and, as such, does not have the industry momentum to compete with the bigger players (i.e. when Apple, Google, etc.) decide to join the party. The company compares itself to Z-wave and ZigBee, and believes both have significant issues (i.e. they don’t do powerline, the need a separate controller, etc.). But in the long run, Insteon will be relegated to a small piece of the puzzle, as manufacturers continue to sink money into protocols with larger players and more momentum.

**The Google and Apple Affect**
As noted in my Blog, Apple v. Google: The Gloves Come Off in the Home both Apple and Google have recently provided insight into the direction they play to push the home automation market. Both Google and Apple obviously have the ability to greatly affect the home automation market.

Google’s purchase of Nest Labs and the subsequent introductions they have made to the market have shown us their strategy is entirely revolving around Android and the cloud. Nest’s intention is to become the central platform for Internet of Things’ [IoT] connectivity in the home. The Nest developer program was introduced with partners Mercedes-Benz, Jawbone, IFTTT, Logitech, LIFX, and Whirlpool, all connecting their devices to the centralize cloud controller through Nest.

This is just the beginning. With an open developer platform we are going to see all the typical home automation functions connecting to Google’s central cloud platform, all through your Nest. One can easily image where this is headed. Your Jawbone will be able to talk directly to your dryer, your car directly to your lights, etc. Each of the connected devices will be able to communicate directly through the Nest thermostat.

Prior to the Nest API announcement, Nest Labs announced the purchase of IP webcam provider Dropcam. Purchasing Dropcam and pairing it with Nest's products is the first step in Google/Nest’s building out their hardware portfolio for a home automation platform.

Apple has taken a different strategy with their announcement of HomeKit. HomeKit is a smart-home iOS software framework that enables discovery and control of third party connected devices by an iPhone or other iOS device. Many of today’s smart devices are controlled by a dedicated application (Belkin WeMo, Nest, Philips Hue). Apple allows multiple devices to be controlled by a central app, and, of course, Siri.

Apple’s strategy, at least for now, is to stay out of the hardware fray, and focus on their own existing hardware with new software on top. In addition, Apple provides the ability to develop “scenes” or groupings of devices such as “time for bed” which could adjust lights, thermostats, etc..

Apple strategy is focused on increasing their value with existing customers and initially staying out of the competitive hardware segment. Apple users can now assume that the iOS device in home owners’ hands will be THE controller for their homes. By encouraging vendors to build around supporting the iPhone as opposed to focusing on the infrastructure wireless technologies, they can guide the market without having to make a large investment in hardware products for a fractured market. I expect to see Apple take a further step and introduce products (other than AppleTV) for the home, but not until they have solidified the iPhone as the controller of choice for Home Automation.

Industry Consortiums
Recently a number of industry consortiums have formed to tackle the issues revolving around the multitude of standards in the home.

The [AllSeen Alliance](https://www.allseenalliance.org), led by the Qualcomm, is a consortium of companies which collaborate on an open, universal Internet of Everything software framework based on AllJoyn, originally developed by Qualcomm, but now released to developers as open source code. This allows devices and services to be connected regardless of brand, transport layer, platform or operating system. Members include industry figures in consumer electronics, home appliances, service providers, retailers, automakers, cloud service providers, enterprise technology firms and startups. Names included are Microsoft, LG, Sharp, Panasonic as well as others.

Recently technology industry leaders Atmel, Broadcom, Dell, Intel, Samsung Electronics and Wind River, joined forces to “establish a new industry consortium focused on improving interoperability and defining the connectivity requirements for the billions of devices that will make up the Internet of Things (IoT)”. The [Open Interconnect Consortium (OIC)](https://www.openinterconnect.org) is focused on defining a common communications framework based on industry standard technologies to wirelessly connect and intelligently manage the flow of information among personal computing and emerging IoT devices, regardless of form factor, operating system or service provider.

Finally, Nest Labs, Samsung and others including ARM, Freescale, Big Ass Fans, Silicon Labs, and Yale Security have just launched [Thread Group](https://www.threadgroup.org). Thread Group was formed, “To create the very best way to connect and control products in the home,” and was designed with the following features in mind:

- Simple for consumers to use
- Always secure
- Power-efficient
- An open protocol that carries IPv6 natively
- Based on a robust mesh network with no single point of failure
- Runs over standard 802.15.4 radios
- Designed to support a wide variety of products for the home: appliances, access control, climate control, energy management, lighting, safety, and security

All three of these industry consortiums will have an effect on the home automation market long-terms. However, we believe the effect will be mostly in terms of software layers and security rather than dealing with the actual transport mechanism. Both of these alliances have major manufacturers involved in Wi-Fi, Bluetooth, ZigBee and Z-Wave and have a vested interest in the continued success of these technologies.

**Conclusion**
Low-end mainstream and DIY Home Automation consumers desire the cheapest and easiest ways to connect to devices they want to use in their homes. They want to connect using controllers they already have, and they want them to be able to retrofit easily into their existing home environments. They also want all these devices to work together, and for them to be able to control them from a single software interface. Whether a low-end mainstream user engaging an installer to help them design and integrate their system, or a pure DIYer, when it comes to making wireless choices for the home will be driven by the same factors.

1. **The home automation controller of choice for low-end mainstream and DIY consumers will be smartphones and tablets.** Both of these segments are cost conscious, and they already have these devices in their homes. These segments are, and will be, dominated by Apple and Android operating systems and applications that control home automation systems running on these platforms.

2. **Wi-Fi will be successful.** Wi-Fi is ubiquitous in these market segments, and as the backbone to the internet, it is the easiest and cleanest choice for controlling the home. Since almost every home is already Wi-Fi equipped, the easiest and cheapest way for consumers to add functionality to the home is to add Wi-Fi endpoints. Whether lights, security systems, or locks, they all can be connected via Wi-Fi. To take full advantage of its future potential in the home, Wi-Fi must continue to drive the cost and power curves lower.

3. **Bluetooth should be successful.** The home connectivity market will be fragmented for years to come. Consumers are more driven by the requirement for a single application interface to control their homes, rather than what technology connects them. Apple HomeKit drives home the need for this model. Based on the current usage by Apple of Bluetooth and Wi-Fi, we also believe Bluetooth will be successful in the home automation segment. The have a competitive technology, strong backing and name recognition.

4. **Companies that integrate Wi-Fi, Bluetooth, Z-wave and ZigBee through a single controller (Revolv, Nexia) will be successful, at least for the next 5 years.** These controllers provide a simple way for DIYers, a growing segment, to add home automation features and functions into their existing environments. As long as these companies provide an easy to use software interface that supports key consumer products (WeMo, Hue, etc.), consumers will buy these products.