



BUILDING INTELLIGENT CONNECTED HOME SOLUTIONS:

Challenges & Ways to Overcome
Them





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SUMMARY

What makes connected homes smart?

Obviously, it's advanced data processing capabilities and automatic device configuration, which is currently missing from the majority of Home Automation products.

What we have now is a \$ 48 billion market driven by Google, Amazon, Apple and thousands of smaller IoT vendors. It's fragmented and full of untapped opportunities, but we won't achieve complete automation if we continue to design pseudo-smart gadgets with baked-in connectivity and pairing them to Android and iOS apps via BLE.

What we need is advanced Home Automation products which would recognize users' faces, identify a person with 100% accuracy, automatically adjust its settings based on homeowners' preferences and work in sync with other devices to make data-driven decisions.

How can Smart Home developers possibly reach these goals?



LIMITED COGNITIVE CAPABILITIES: THE BIGGEST BARRIER TO INCREASED HOME AUTOMATION



The era of meaningful Home Automation started with the release of Nest Thermostat.



The small gadget that “lives on your wall and in your pocket” (because, as we mentioned earlier, most Smart Home products are operated via a mobile app) offers a smart way to manage HVAC systems as it does not simply allow homeowners to adjust and monitor temperature but detects patterns in their behavior and manages its settings without human interference.

Powered by light and motion sensors spotting activity in a room, as well as three temperature sensors to take more accurate measurements, a humidity sensor and built-in Wi-Fi connectivity facilitating data sourcing and firmware updates, the thermostat introduced a whole new way to control HVAC equipment and optimize energy consumption.

In approximately seven days after the installation and manual adjustment Nest creates an operating schedule based on a user’s preferred settings and local weather forecasts. Over its lifetime, the device continues to learn users’ habits and upload data to their Nest accounts in the cloud. It automatically turns HVAC systems down when you’re away, activates them at a preset time and provides daily energy saving reports.

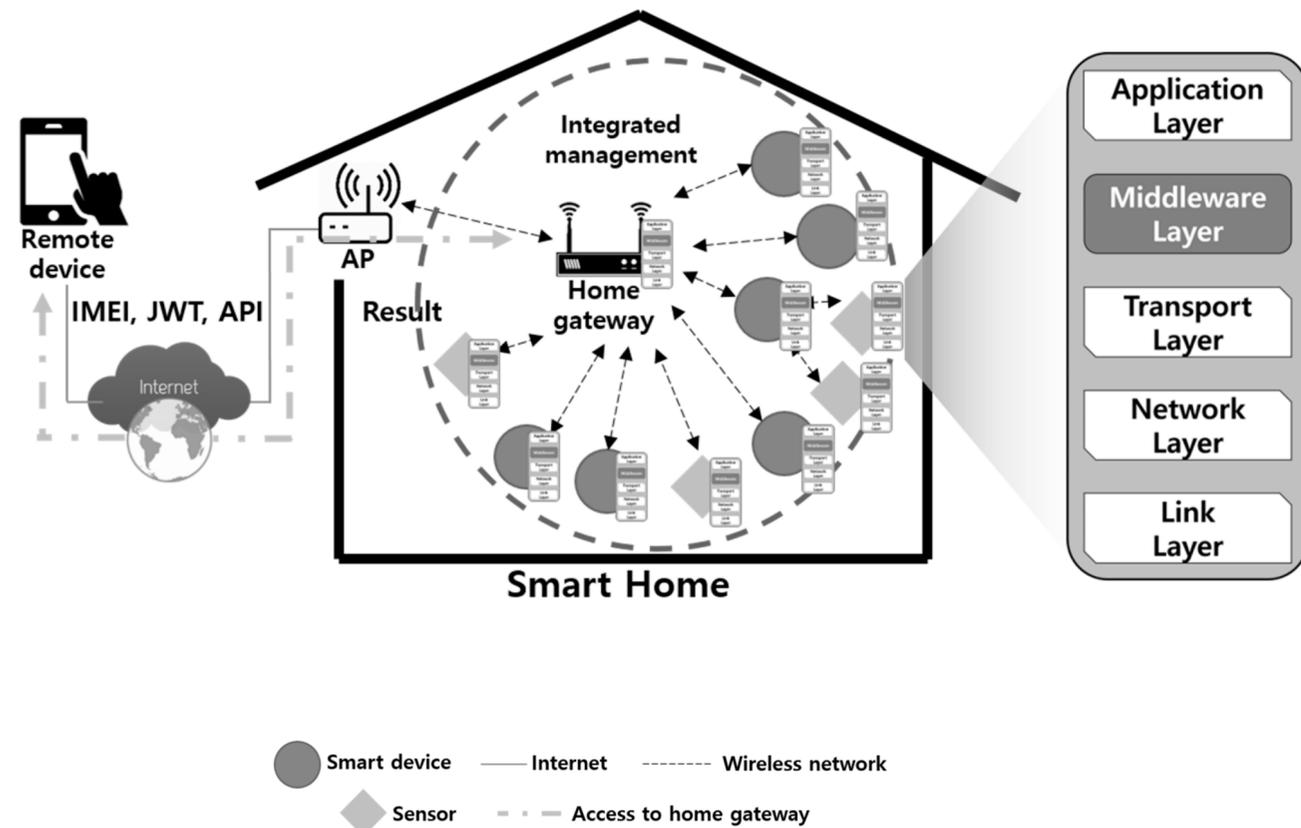
The Nest product line now includes a connected smoke detector, indoor and outdoor security cameras and a smart doorbell based on facial recognition, which are — thanks to the company’s Works with Nest program — compatible with over 30 gadgets including Amazon Echo and Philips Hue.

The supervised learning algorithms which enable Nest cognitive capabilities do a reasonable job when applied to a small amount of data collected via a limited number of sensors; challenges will arise if we implement the same technology in multi-level Smart Home solutions composed of various devices. Nest’s decision to enhance AI used for its products and facilitate situational decision making proves the fact that the future of Home Automation largely depends on Machine Learning.



COMBINING SMART HOME TECHNOLOGY WITH MACHINE LEARNING: HOW DO SUCH SYSTEMS WORK?





Technology-wise, an AI-powered connected home operates on two levels: hardware and software.

These feature several sublayers including:

- sensors
- stationary control devices (haptic feedback is desirable)
- central hub (which orchestrates Smart Home devices within the system)
- cloud server (where data is stored and analyzed).
- secure communication protocols
- mobile, tablet or desktop apps (responsible for data visualization and management)

The devices which comprise an AI-powered Home Automation system should be able to provide services both to each other and to the end user and continuously acquire new data for further learning.



Since smart devices act as independent modules, the system should use a combination of service-oriented and event-driven architectures where the components talk to each other via communication protocols and can be updated, managed and configured separately.

It is the cloud-based data analytics module where raw sensor readings are processed and data patterns are identified, so the system knows event A (a homeowner unlocks the front door) is usually followed by event B (the heating is turned up).

With those data patterns, a Smart Home system should be able to predict a user's behavior based on historical (that's what Nest thermostats do!) and real-time data to develop the so-called situational awareness — i.e., understand a user's intentions at a given moment and change parameters accordingly.

In an ideal world, it may look like this:

Monday to Friday, Mary's alarm clock goes off at 7 am. Her Smart Home system turns the thermostat up and, knowing that Mary prefers latte in the morning, sends a notification to the connected coffee maker. On the weekends, however, Mary likes to have a lie-in and starts the day with a fresh-made juice — and the Smart Home never fails to adjust its settings accordingly.



WHAT PREVENTS SMART HOME VENDORS
FROM ACHIEVING THIS KIND OF
AUTOMATION IN THE REAL WORLD?





TOP 3 HOME AUTOMATION CHALLENGES TO BE SOLVED





CONFUSION OVER WHAT A SMART HOME REALLY IS

As you can see, a Wi-Fi self-learning thermostat is not really a Smart Home device; instead, we can talk about “connected home” or “partial Home Automation” solutions.

A truly intelligent Smart Home is a multi-component system which requires little to no management on a user’s part and is capable of making decisions based on historical and real-time data.

Thus, the solution should be able to identify significant user actions (Mary’s woken up), assess the probability events those actions trigger (it’s time to turn the thermostat up) and issue appropriate commands to other devices within the network (it’s Sunday, so Mary is having juice instead of coffee).

High as it is, the current level of AI development does not allow neural networks to evaluate the factors driving a user’s behavior as good as us humans — and we are not even talking about sentiment analysis here.



CLOUD TECHNOLOGY SHORTCOMINGS

Using cloud solutions — for instance, Amazon Web Services (AWS) — does not always make sense in Home Automation. Here's why:

- A connected home solution should be available even if the Internet goes down.
- Few users are willing to share personal data with a cloud service provider for security reasons.
- In case a smart device manufacturer decides to discontinue cloud support, a user is left with an expensive and largely useless gadget.

It doesn't mean Home Automation companies should give up cloud technologies entirely: after all, data storage and analysis require dedicated servers, which would increase Smart Home development and production costs and undermine the whole idea of a connected home which, among other things, should be energy-efficient.

Ways out?

Companies eyeing the Home Automation market can turn to Machine Learning-as-a-Service (MLaaS) solutions like IBM Watson, Amazon ML, Microsoft's Azure ML for complex behavioral data analytics and store sensor data locally (for instance, on SD cards).



SMART HOME MARKET FRAGMENTATION

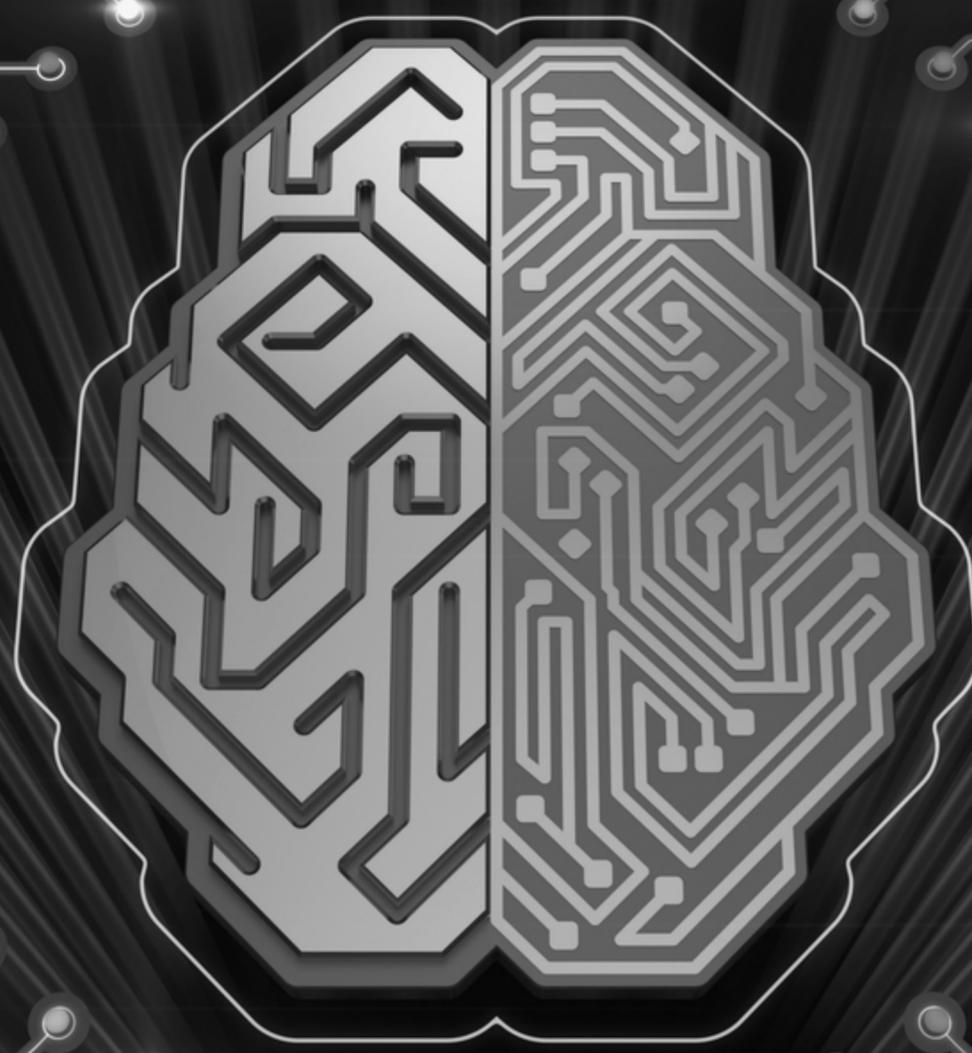
In order to set up a secure, scalable and highly functional connected home solution, a user has to connect gadgets created by different vendors — and few Smart Home solutions are designed to communicate with 3rd-party products.

Over the last couple of years a few steps were made to solve the Smart Home interoperability issue.

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With the introduction of Z-Wave and open source Home Automation APIs including Google's Home Assistant RESTful API, Amazon Alexa Smart Home Skills, Yeti and Lockitron, connected home manufacturers can integrate their devices with quite an impressive number of Smart Home solutions.

Still, a random Wi-Fi switch in your bedroom won't persuade your coffee maker to brew a cup of Americano (unless we're talking about the WeMo/Mr. Coffee/Alexa situation), so investing in middleware will remain a necessary evil for now.



MACHINE LEARNING APPLICATIONS IN HOME AUTOMATION



Although Smart Home solutions aren't likely to master context-based decision making in the foreseeable future, machine learning can make connected homes a lot smarter.



Security Solutions Powered by the Facial Recognition and Biometric Access Control Technologies

FACIAL RECOGNITION

Smart Home security systems which employ the facial recognition technology incorporate connected video cameras and are powered by artificial neural networks. The networks, in their turn, are capable of identifying facial landmarks — for instance, eyes, cheekbones, nose and chin — in a person's photo and compare the data to the imagery produced by cameras.

A simple way to create a prototype of such systems is to pair video cameras to a Raspberry PI microcomputer via Wi-Fi. A face recognition module is the system's trickiest element; unsupervised machine learning algorithms are usually trained with the help of open source computer vision tools like Azure's Custom Vision Service and Amazon Recognition. An AI-based security system can successfully identify the faces of a home's residents and send notifications about suspicious activity to a homeowner's smartphone.



The R-Style Lab team has created an MVP of an advanced video analysis system which makes use of a portable video camera, Arduino and Raspberry PI boards and image acquisition and recognition libraries; you can read the case study [here](#).

There are several examples of such solutions available on the market:

- **Honeywell**, a Smart Home security system which features a set of outdoor surveillance cameras and an Echo-like speaker with an embedded camera. Besides the facial recognition technology, the system also supports Alexa.
- **Netatmo**, an indoor security camera which allows users to disable video recording for familiar faces and sends notifications to the dedicated smartphone app once a stranger is caught on camera.
- **Ooma**, a home security system featuring door and window motion sensors, the Butterfleye camera and a two-way voice interaction mobile app.



FINGERPRINT RECOGNITION

Biometric access control solutions are mostly limited to door locks such as August, Kwikset Kevo and Samsung; most of these products can be seamlessly integrated into Amazon, Google or Samsung Smart Home ecosystems.

Biometric door locks usually take photos of a user's fingertips via optical scanners and store them for matching (once again, a computer vision solution is required) or use two-factor authentication (fingerprints and passwords).



VOICE INTERFACE-BASED SMART HOME MANAGEMENT SOLUTIONS

Voice-activated Smart Home products rely on the voice recognition technology which captures spoken words, digitalizes sound by taking precise measurements of a sound wave, removes background noise and passes the data for further analysis. During the process, digital signals are broken down into smaller samples; their length depends on the duration of a sound produced by human vocal cords. These data patterns are compared with the phonemes of a target language, interpreted and acted upon — i.e., connected gadgets within a Home Automation system execute commands issued by the voice assistant.

A prototype of a Home Automation solution which makes use of the voice recognition technology can be created with a Raspberry PI board, sound card and an NLP tool like Amazon Transcribe and Azure Custom Speech Service. Furthermore, one can choose a 3rd-party Intelligent Personal Assistant (IPA) like Siri, Alexa or Google Home to streamline connected home development and optimize costs.



Voice commands are usually preceded by a wake word such as “OK, Google”; the system isolates a person’s voice from background noises, converts the audio to a digital file and sends it to the cloud for NLP analysis. The cloud-based server then mines the meaning from other resources, as well as the Smart Home’s own database, and generates an appropriate response or triggers an action.

Although most 3rd-party AI assistants only perform well under ideal circumstances (neither Alexa nor Siri can capture voice commands with the background music playing, for example), Home Automation companies can improve the accuracy of voice assistants using noise reduction chips.



ON THE WAY TO HOME AUTOMATION

The goal of Home Automation is, well, complete automation, which is currently missing from many current Smart Home offerings. With machine learning, however, companies can significantly minimize the inconvenience for connected home owners who often have to set up and operate their not-so-smart devices manually.

As a company with hands-on experience in Smart Home software development, R-Style Lab believes image and voice recognition have the most potential within the competitive domain.



WHAT DO YOU THINK? WHICH TECHNOLOGIES
DOES YOUR START-UP USE TO OVERRIDE
MODERN SMART HOME LIMITATIONS? JOIN US
ON SOCIAL MEDIA TO DISCUSS YOUR HOME
AUTOMATION PROJECTS!



ABOUT US

Founded in San Francisco, CA, in 2006, R-Style Lab has now grown its global footprint to operate in Europe. The company's business office is located in the United States and delivery facilities are based in Minsk, Belarus. We build the entire app ecosystem for your IoT solution – mobile, web, wearables & low-level software – providing professional assistance across the full-cycle of custom software development. R-Style Lab acts as a single-point-of-contact service provider for businesses that operate in the reality of data-driven and connected economy.



PAVEL SHYLENOK, CHIEF TECHNOLOGY OFFICER

With a Master's Degree in Informatics and Electronics and over 10 years of experience in IT and software development, Pavel has helped hundreds of B2B & B2C companies optimize their IT infrastructures, automate time-consuming processes and deliver the ultimate customer experience. When Pavel is not busy saving the world, he's eager to share his wisdom and expertise with you!

ANDREI KLUBNIKIN, SENIOR CONTENT MANAGER

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