# Smarter Home Automation Landscape Analysis

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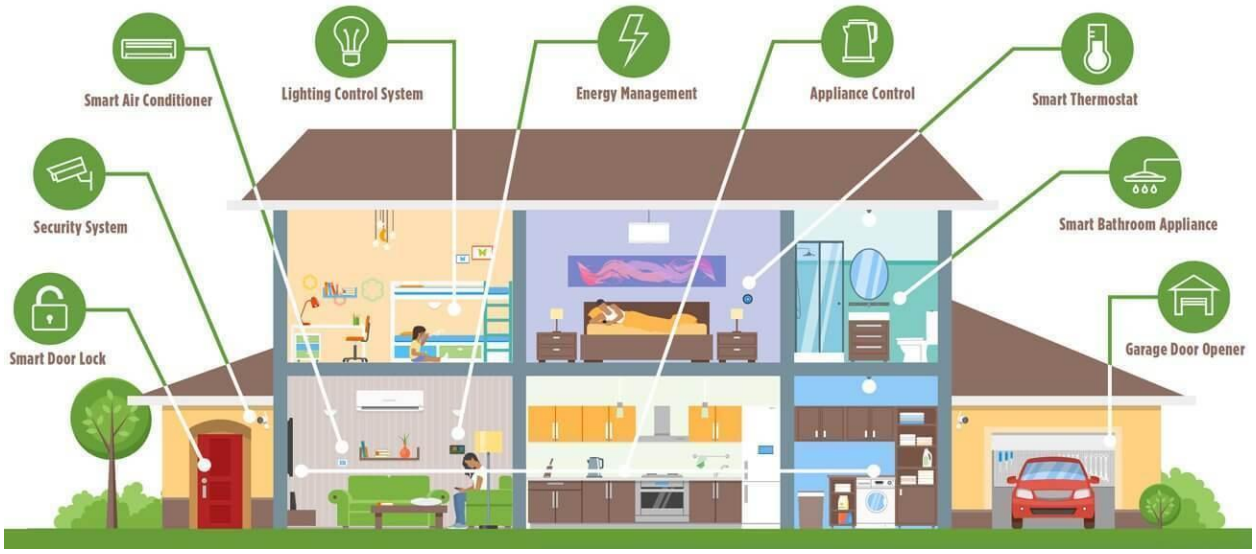
# 1 Introduction

The Internet of Things (IoT) is slowly permeating every aspect of our lives. A Smart Home is a house that has a communication network that connects multiple different IoT devices and allows them to be remotely controlled, monitored and accessed. Smart home technology promises to make the home more comfortable, more convenient and more secure. The vision of the connected home is finally beginning to come together. Connected devices are disrupting every nook of the home[1]. From smart thermostats to smart coffee makers, IoT devices are slowly but surely garnering mainstream adoption in the home.




[2]

With technological advances in voice control and artificial intelligence, the intelligent assistant is now a viable control center for the connected home. Despite the proliferation of devices, we're still far from the vision of seamlessly connected homes. Currently, there is a lot of manual input required to achieve optimal functionality—there is not a lot of intelligence built in. You must set your alarm, tell your coffee maker when to start brewing, and manually set schedules for your thermostat, all independently and precisely. Current Smart Home devices interact with the end user. These devices rarely have any intelligent interactions with each other, and hence the user is left playing the

role of master orchestrator, a labor intensive job[3]. This means that almost all decision making requires human interaction.

# 2 Current State Of Home Automation


## 2.1 Use case without Smart IoT

We followed Arvind, our made up subject, for a day to better express what the current challenges are with home IoT are. In a later section we will go through the same timeline to understand how smart IoT would have handled the situation better.

- **6:30 AM** – Arvind woke up for an important meeting but realized that a crash on I-280 meant he would reach late.

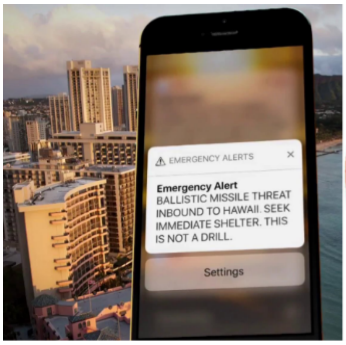
- **6:45 AM** – Arvind takes his daily dose of vitamins but he isn't taking enough for the vitamin D deficiency he has.
- **7:00 AM** – Arvind sits down for breakfast but realizes the milk has expired and has turned sour.
- **11:45 AM** – A UPS driver leaves a package on Arvind's porch but 15 mins later it is stolen by an intruder. He had turned off his camera motion notifications since it tripped unnecessarily very often and once cost him $200 because the police were called out.
- **1:00 PM** – Arvind's older parent falls while climbing down the stairs and cannot get to a phone to call for help.
- **3:00 PM** – Arvind's kids return from school but they forgot their keys at school.
- **6:00 PM** – Arvind wanted a healthy salmon dinner but he doesn't have any salmon at home.
- **9:00 PM** – Kids in bed and Arvind jumps on the scale on realize he has put on 20 pounds.
- **11:00 PM** – Arvind is in bed but can't get himself to fall asleep for a big work day tomorrow.

## 2.2 Alarm fatigue

In fact Arvind got a notification from his "smart" security camera at 11:45 AM notifying him about motion detected in his front yard. However, Arvind decided to ignore the alert since it was the 10th notification that morning. On a typical day he receives around 20 notifications, all of them false alarms.

The root of the problem is that current smart security cameras trigger an alarm or notification when it senses motion. However, it does so without consideration for what caused the motion. The system is unable to determine if the motion is caused by an occupant of the home? Is it the mailman? Is it a tree branch swaying in the wind?

False alarms cause alert fatigue and results in recipients ignoring alerts.








Unfortunately for Arvind the alert that morning was notifying him of the package theft and he decided to ignore it.

# 3 Smarter Home Automation

IDC estimates that the number of devices connected to the internet will surge from 11bn in 2016 to 80bn in 2025, with a corresponding boom in data generation from 4.4 zettabytes of data in 2013, to 44 zettabytes in 2020 and on to 180 zettabytes in 2025. With such rapid proliferation of devices and generated data, having a human in the decision making process will not scale. Much more than what smart devices can do, the value is going to be in what can an user offload from his or her mind.

Example #1: Smart refrigerator detects expired milk and orders a fresh bottle of milk of the right size and brand based on your usage and preference.

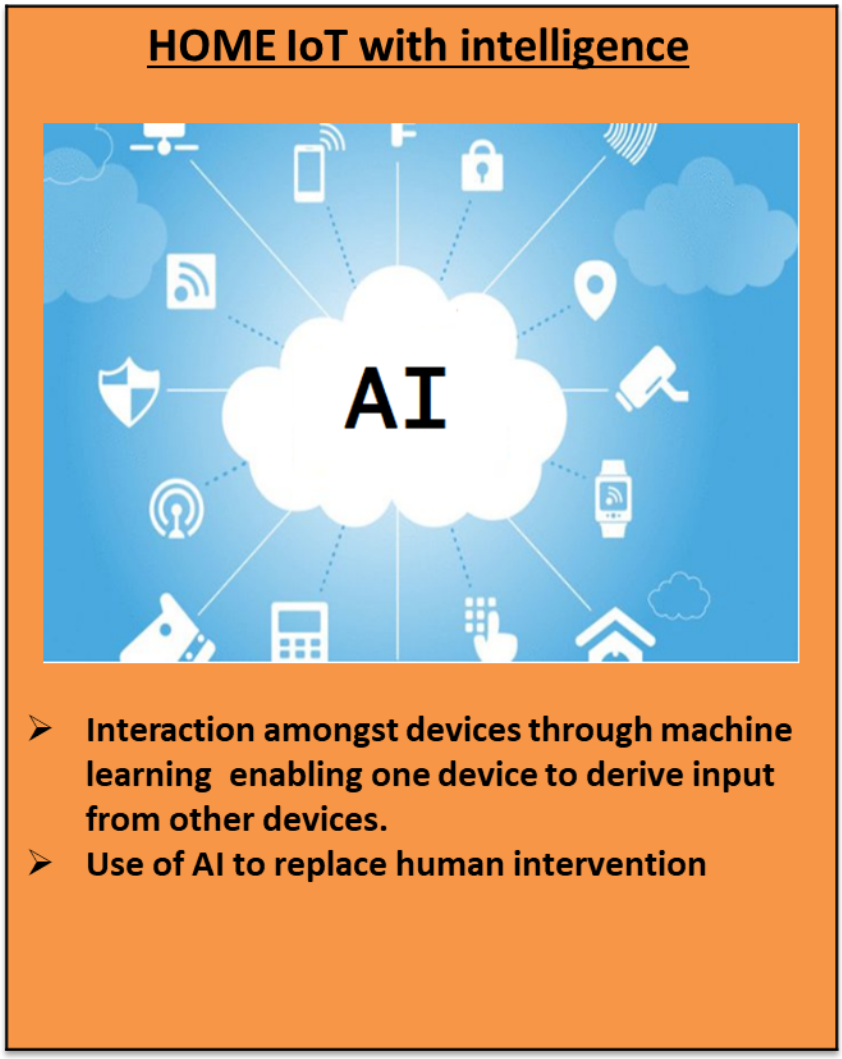
Example #2: Smart security camera is aware of the scheduled UPS delivery and is expecting it. When the UPS truck arrives, it is able to confirm that it is indeed UPS and opens the garage door for the UPS driver to leave the package in the garage.

## 3.1 AI in Home IoT

Smart Home technology needs to evolve to take care of mundane things thus freeing up time for the really important things. Data is only useful if it creates an action. To make data actionable, it needs to be supplemented with context and creativity. AI can analyze large amounts of data from multiple sources supplementing it with context to derive knowledge. AI + IoT brings ‘Connected Intelligence’ rather than just connected devices. Connected Intelligence helps make decisions and coordinate actions with other devices.

A true Smart Home solution needs to have Connected Intelligence. It needs to be aware of the presence of the people who live in the house along with their personas; it needs to be aware of what they’re doing; it needs to be even aware of what every device in the house is doing. To truly unlock the potential of smart home, the house needs to think

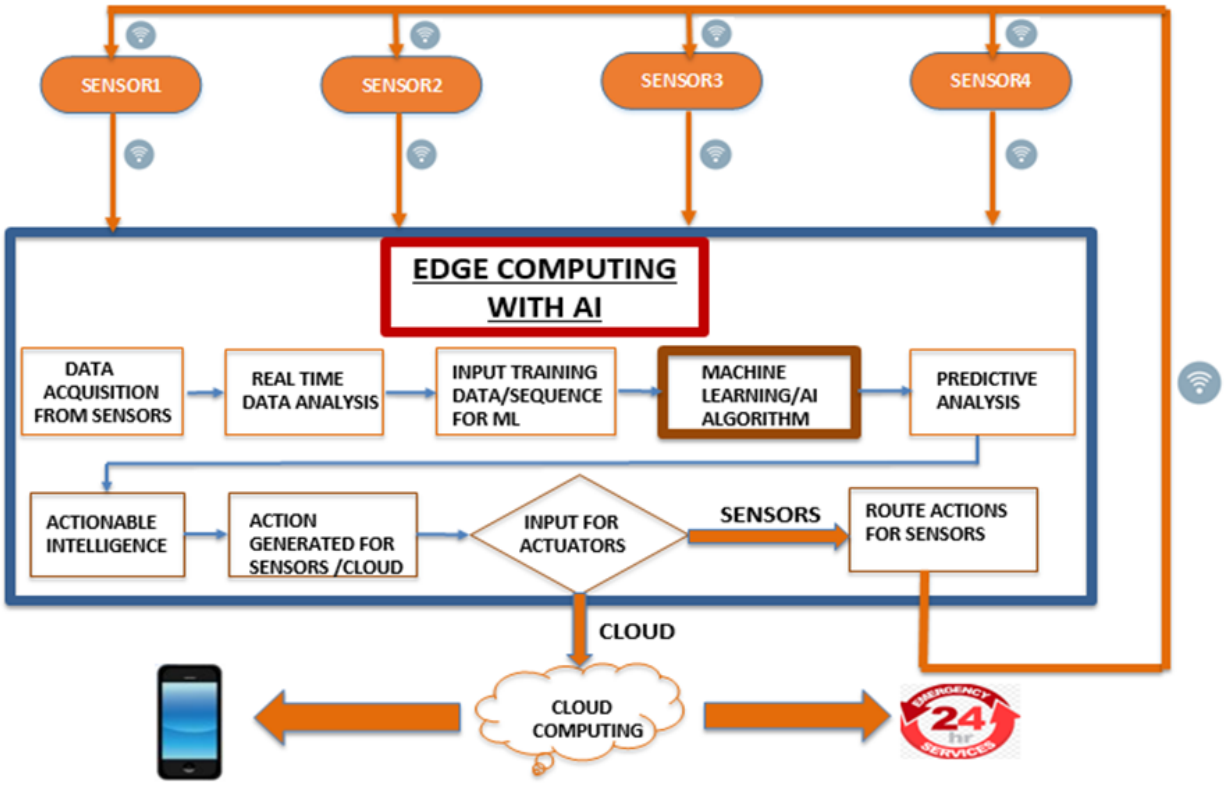
like a human, the house needs to be able to analyze the data a human would analyze before making a decision.




A key challenge with current Smart Home solutions is interconnectivity. i.e. either the smart sensors are working as standalone units or getting operated through human interface. e.g. Google home, Alexa,etc. Although this provides end to end control of all smart sensors which are operated inside the smart home along with personalized use case, it can lead to significant overhead on the user controlling these sensors. Many of the actions derived as input for one sensor are output for the other sensors in the Smart Home. Since these inputs and associated actions derived from these are deterministic based on the individual use case, human intervention can be minimized and replaced

with an AI based smart computing solution which can be fine tuned based on typical and past use case of the homeowner.

The actions derived out of AI based prediction can be for the sensors inside the smart home (Edge) or between devices at edge and cloud. Since there can be simultaneous multidirectional interaction between the smart sensors and concurrently output getting generated for cloud computing, it's critical the entire data flow gets managed through a centralized AI processing unit as illustrated below:




This processing unit acts as a hub for the data acquisition from all the sensors followed by data analysis which gets fed into the the AI based prediction tool to provide predictions and confidence levels associated with these predictions. In order to have better accuracy and higher confidence level on the AI predictions, we must have a large population of training data set with minimum possible noise. It’s important to have a data analysis or data filtration step before feeding data into the AI tool to minimize noise

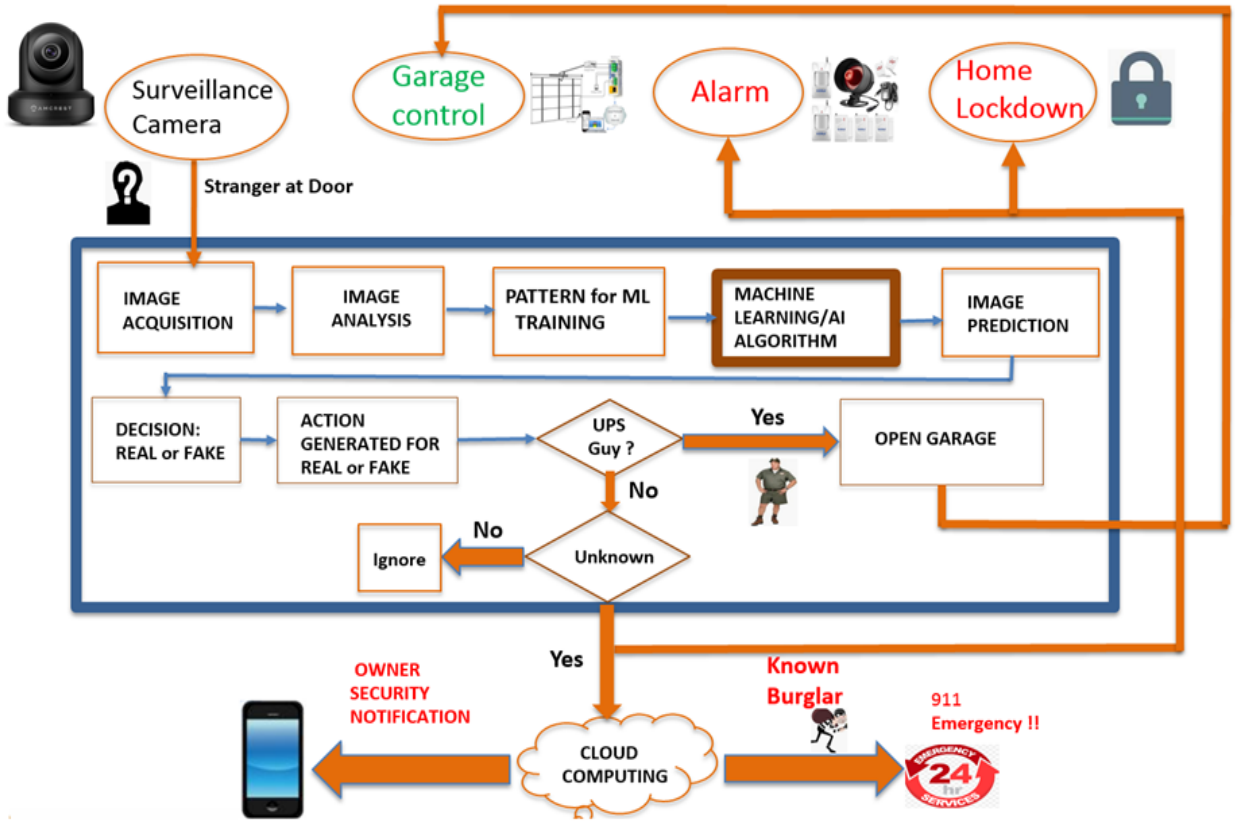
and improve output prediction accuracy. In order to ensure there is actionable intelligence, confidence limits can be assigned for decision making. i.e. high confidence level predictions can lead to inputs for other sensors in the smart home whereas low confidence limit predictions can be ignored or optimized on an ongoing basis. Based on the severity of the problem and confidence level of the prediction, secondary verification step can be added to enhance the prediction accuracy. Based on this, output prediction data can be routed to cloud for emergency situations requiring immediate attention.

There are numerous machine learning based prediction algorithms and machine learning platforms available today. Google Tensorflow, Amazon Machine Learning, Microsoft Azure, IBM Watson to name a few available platforms. Any of these ML platforms can be configured and plugged in for providing smart home IOT solution.

In the limited use case of the UPS delivery, the image acquisition from the camera at the home entrance door needs to be fed into the AI tool in order to predict and decide on following predictions and associated actions :

| **AI prediction (with very high confidence level)** | **Action** |
|---|---|
| UPS delivery person | Open garage door to let the delivery be safely dropped inside the garage. Secondary check can be added prior to opening the garage door to ensure home security is not compromised |
| Recognized person (e.g. occupant of home, mailman,neighbor, etc.) | No specific action in case of mailman. Unlock main entry door if home owner |
| Suspicious person movement around house | Alarm or lockdown house,send image to cloud & notify homeowner |
| Match with known burglar image from | Notify house owner and Public Safety in |

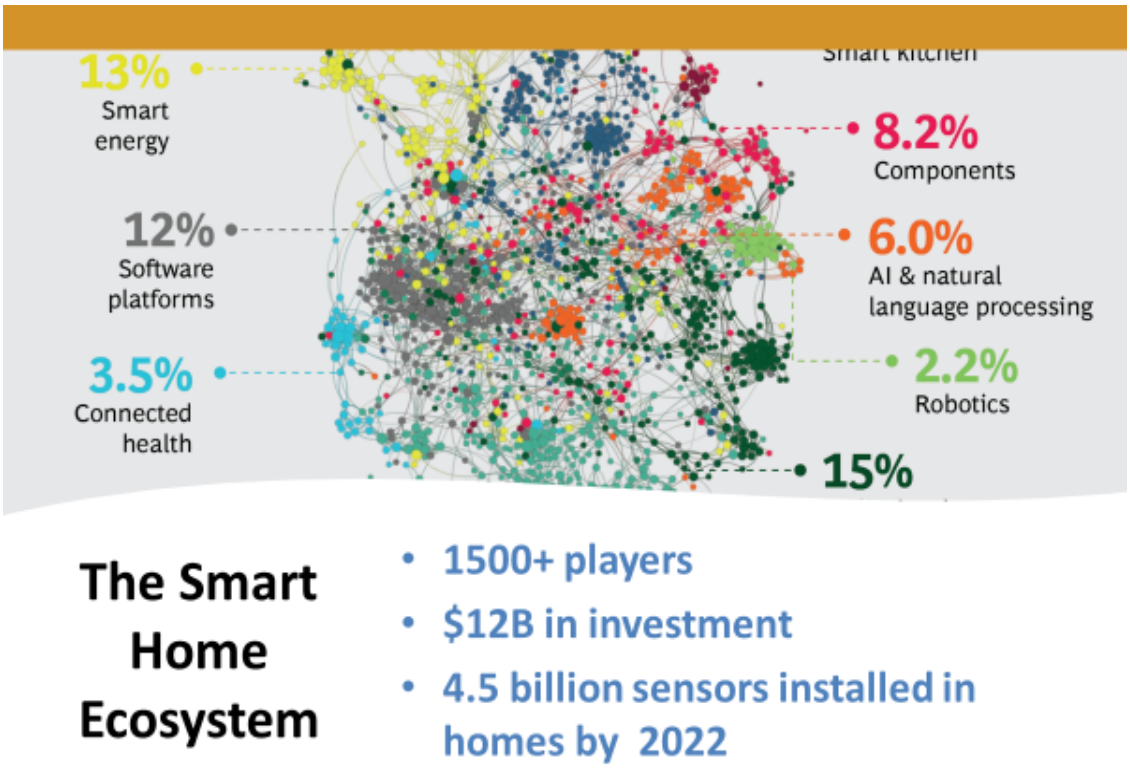
| | |
|---|---|
| Cloud database | addition to sounding an alarm and locking down house |




The AI based processor aggregates input from multiple devices and based on AI based decision making derives actions on one or more connected devices and also acts as a gateway to the outside world through cloud interaction. Communication amongst the sensors at edge can happen over IEEE protocol and the communication between Edge

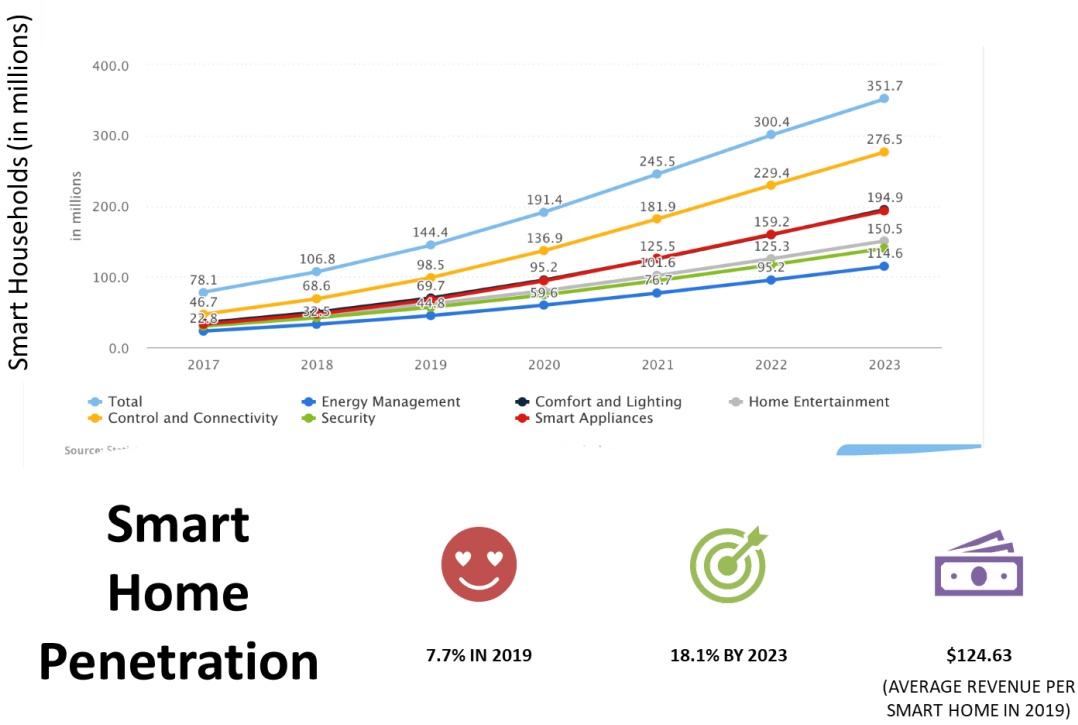
and Cloud can take place over mobile communication system. AI based decision making can be done at the edge, on the network or at the cloud as applicable.

# 4 Home Automation Market




The smart-home ecosystem is continuing its rapid expansion, exemplified by Amazon's acquisition earlier this year of Ring, a maker of internet-connected doorbells and cameras, for an estimated $1 billion—the second-largest acquisition in the company's history. That followed big-dollar purchases of Nest (maker of smart thermostats, smoke detectors, and other products) by Google and of SmartThings (maker of a smart-home platform) by Samsung, as well as Apple's financial commitment to Echelon, another platform maker. Investments in smart-home technologies are soaring, and so are adoption rates as consumers start to perceive products ranging from voice-activated assistants to smart security systems as standard household items rather than unnecessary luxuries.

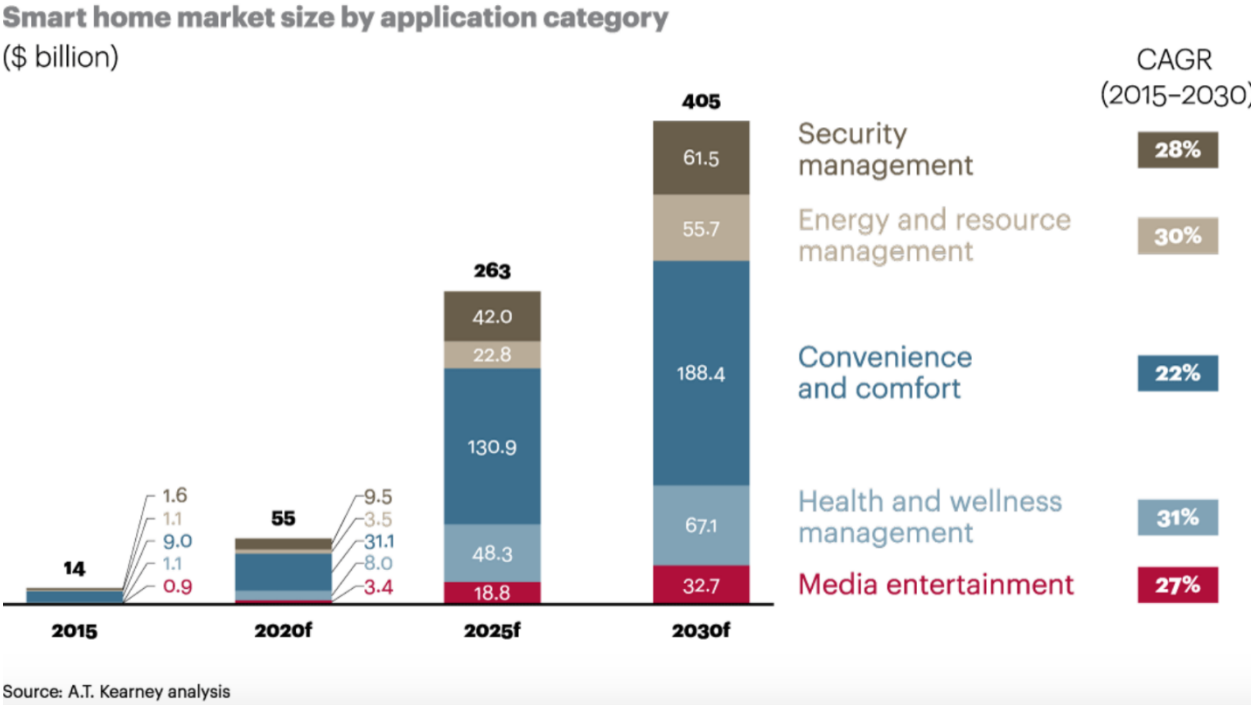
There are about 1500 players in the smart home market; broken down into 11 sectors; and these acquired about 12 billion in investments.




Source: Statista, March 2019

By the end of 2018, there were an estimated 20% of homes that were considered “smart homes.” To be considered a smart home, the home has to include more than one internet-connected device, such as a TV, lights, appliances, locks, thermostats, cameras, and more. With companies like Amazon, Google, and others consistently coming out with new and improved smart home technology, we can expect more consumers to adopt the use of smart devices in the home. In fact, data reported by McKinsey states that the annual growth rate for the connected home industry is 31% and only expected to increase.

**Smart home market growth will explode after 2020**




Source: A.T. Kearney analysis

The current global smart home market is worth approximately **$15 billion**—excluding smart TVs and residential solar power systems, which are inherently connected. This number, while hardly negligible, represents just a small share of the segments where smart home devices and applications compete. To take just two examples, the global home appliance and furniture market value (including both smart and non-smart products) exceeds $1 trillion, and the global home security solutions market clocks in at approximately $30 billion. As smart home application prices drop and their availability increases, their penetration will increase too. We estimate the total smart home market will creep up to more than **$50 billion in 2020** and then explode in five application categories to approximately **$400 billion in 2030**, when it will represent more than 40 percent of the total home appliance market.

# 5 Current Players

Do such solutions exist?... We surveyed a few companies and concluded that most of the technology focus is on making smarter sensors rather than smart connected solutions.

**AI Sensors:** detect / recognize / alert

| | emza Visual Sense | HIKVISION | SIMCAM |
|---|---|---|---|
| AI-enabled hardware | • human /object classification<br>• gesture recognition<br>• visual context awareness<br>• people counting analyses | • facial recognition,<br>• face matching / searching<br>• people counting analyses | • facial recognition,<br>• pet monitoring,<br>• location training |
| Data Analysis | • **Edge** (proprietary ML based Computer Vision system) | • **Cloud** | • **Edge**: Intel Movidus |
| Integration | • smart building systems - occupancy detection | • Access control automation<br>• Alarm monitoring service | • human classification<br>• always on |
| Cost/Power | Low power / low cost | Low ASP | N/A |

**Emza**'s always-on visual sensors apply intelligence to improve user experience through superior detection, reducing false alarms, classifying humans and minimizing transmission power. Integrating the custom made CMOS sensors with the Computer Vision algorithms and extremely lean processors yields a sub 1mW, coin-sized IoT sensor, that can detect and classify humans (or any other object), count people, perform queue monitoring and describe the observed activity. The proprietary Machine Learning the sensors can be re-trained for different applications.

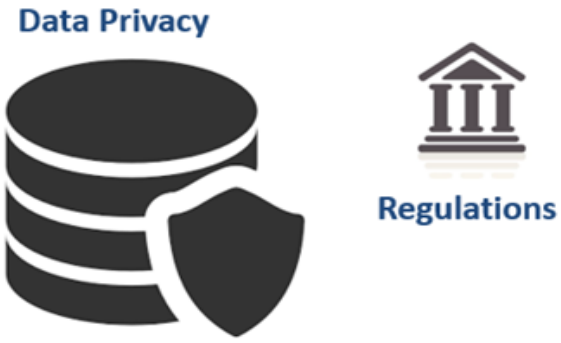
**SimCam** home security and home automation camera with trainable artificial intelligence is using Intel Movidus VPU. The SimCam uses A.I. for facial recognition, pet monitoring, and more via location training. It can also integrate with multiple voice assistance like Amazon Alexa or Google Assistant for voice command control and to connect with other smart home ecosystem devices.

Smart sensors development is focused on the optimization of facial recognition and monitoring technology. Integration with other devices is limited to pairing with voice assistance devices. [4-6]

# 6 Challenges

There are fundamental challenges limiting progress and adoption.

## 6.1 Data Privacy (Govt Regulations)



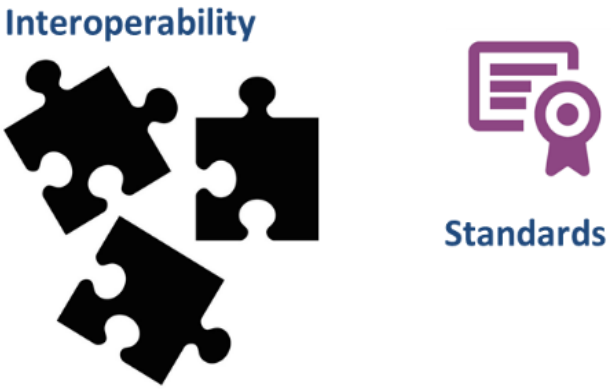

Data privacy is a topic that is neither fully understood by the user nor by the companies. Users don't realize how their data is used and shared by the companies that collect it in order to provide services. Users also don't understand the choices that are available to them in terms of controlling the privacy of their data. Companies also don't do a good job of educating users.

The amount of data generated by a connected smart home where decisions are AI driven, will be exponentially more than what companies need and handle today. This makes the data privacy even more important for the users and at the same time, challenging for the companies to manage. In many cases, companies will also depend on one or more third parties to provide differentiated and reliable services. This will further complicate the data privacy landscape as the data starts to flow to these third parties.

As users understand their rights around privacy and demand choices, the companies that are more transparent in how they use the data are likely to succeed. They will have

to build dashboards that explain users how their data is used. Users will expect options in terms of what they want to share, even if that means a degradation in services or a subset of services. Government will step in with laws and regulations guaranteeing data privacy. We are already seeing this trend with GDPR in EU region and CCPA in California, USA.

## 6.2 Interoperability (Standards)

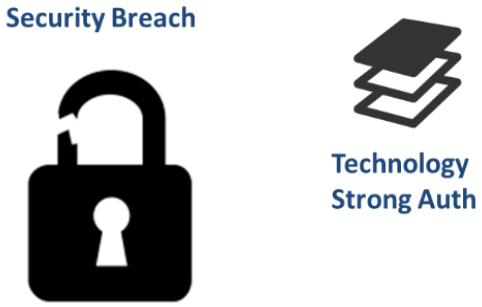



For the multitude of device to coordinate analysis and actions, they must have a common protocol to communicate over. This includes device to device and device to gateway communications. Given the number of vendors that the devices come from, the vendors need to agree to a standards defined protocol for communication. The industry has moved in this direction with lower level IoT protocols such as MQTT but similar efforts will be needed at higher application level protocols.

## 6.3 Latency (5G/Edge)


The need for timely decisions limit the applications relying on cloud computing. Moving the computing to the edge and 5G adoption will mitigate the latency issues. This is especially true of safety decisions where latency can play a major role in the efficacy of the algorithms. Sending data over the network to the cloud and getting back a decision can take 10s of ms while having the decision made on the edge can be orders of magnitude smaller.

## 6.4 Security



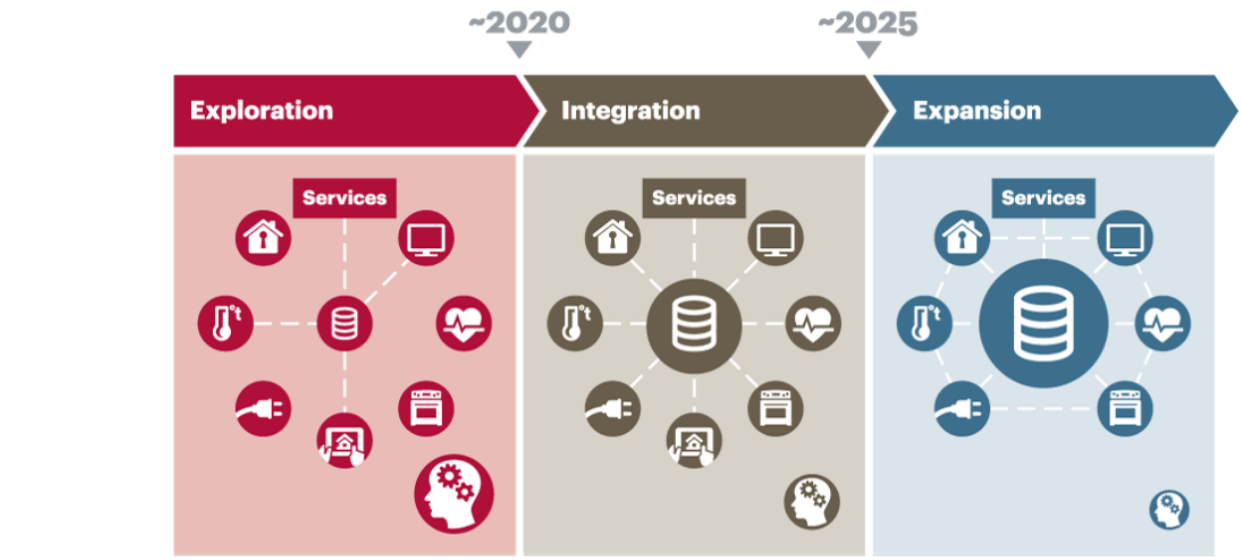

Security breaches while data is in transit and where it is stored is a critical requirement as IoT home automation gets smarter. Smarter home automation not only collects data from the home but also interprets and analyzes it to make trends and actionable inferences. Such information in the wrong hands can be devastating to the homeowner.

Issues such as lateral privilege escalation, where unauthorized access to lower security device can be used to compromise high security devices

# 7 Future of Home Automation

Addressing above mentioned challenges will enable the evolution from today's Smart devices to integrated and personalized home management solutions. When AI-managed interoperability will be common place, the market in the 2nd half of the next decade will be dominated by services for the homebots.

**Evolving smart home concept**




| | Exploration | Integration | Expansion |
|---|---|---|---|
| Inter-operability | Partially connected to the hub | Widely connected to the hub (still some response delays) | Seamlessly connected for all (instant response) |
| Intelligence and automation | Immature AI | More personalized | Products act as a "robot" |
| Product and service offering | New product and service experiments | Integrated product features, such as smart kitchen and smart living | Expanding service offering (as products commoditize) |

Accumulated user data size and data processing capacity size

User effort required to handle products and services

Source: A.T. Kearney analysis

The smart home is often interpreted in various ways, making it difficult to comprehensively grasp the essence of industry trends. Having a clear view of how the industry may evolve, however, is the key for success.

## 7.1 Exploration Phase (Present)

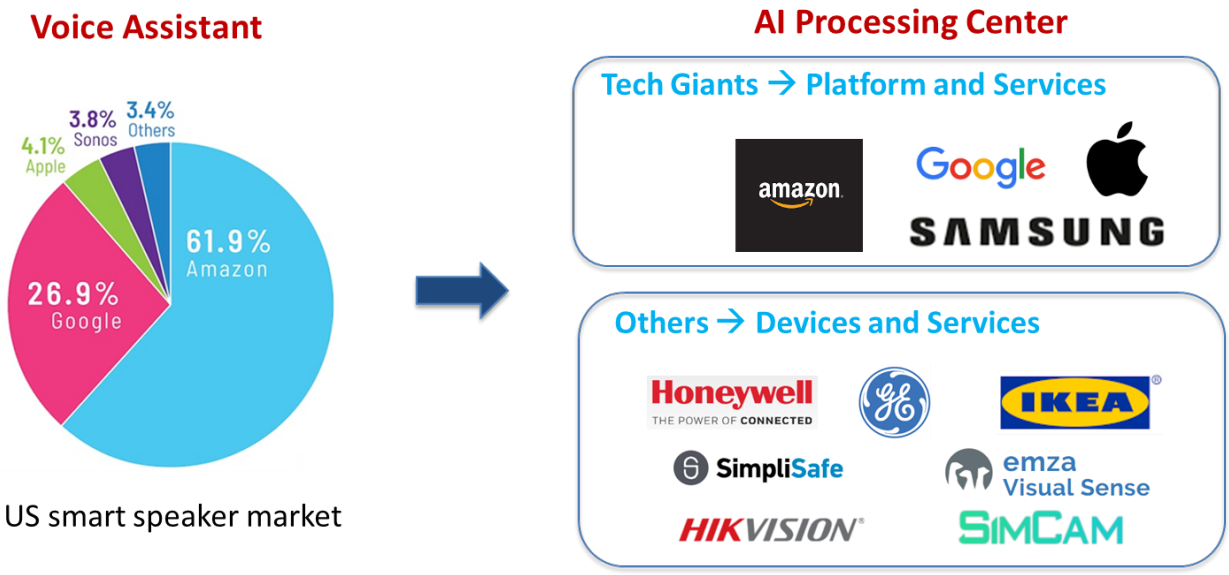
Currently, the smart home industry is in the **exploration phase** where many players are experimenting with new products or services while improving interoperability and advancing AI. So industry ambiguity will continue to linger. Not all home products are smart, i.e. they do not have connectivity.

## 7.2 Integration Phase (2020)

The turn of the decade in 2020 will usher in an **integration phase**: newly purchased home products will be smart by default, incorporating connectivity and certain intelligent functions as standard features. After this point, most electronics products will be widely connected to the hub, and products and services will be more integrated and personalized.

## 7.3 Expansion Phase (2025)

The **expansion phase** will begin around 2025. Interoperability will no longer be an issue, and AI will be very advanced—making smart home products similar to a robot. Around this time smart products will become commoditized and vendors will shift towards services to differentiate and add value to their products.




We expect the big players in voice control to continue to dominate the future of home automation.

- Alexa and similar products will evolve from smart speakers to AI-enabled home managers.
- Platform standardization will enhance their connectivity and market penetration.
- Services expansion will cater to the home devices. Google may go after the enormous amount of data generated by the Smart Homes to mine it for targeted advertising. Whereas, Amazon may plug into the Smart Home to offer a seamless and automatic ordering experience.

## 7.4 Use case with Smart IoT

At the end of this report we circle back to the use case we introduced in the beginning but add how Smart IoT could have greatly improved the Arvind's day

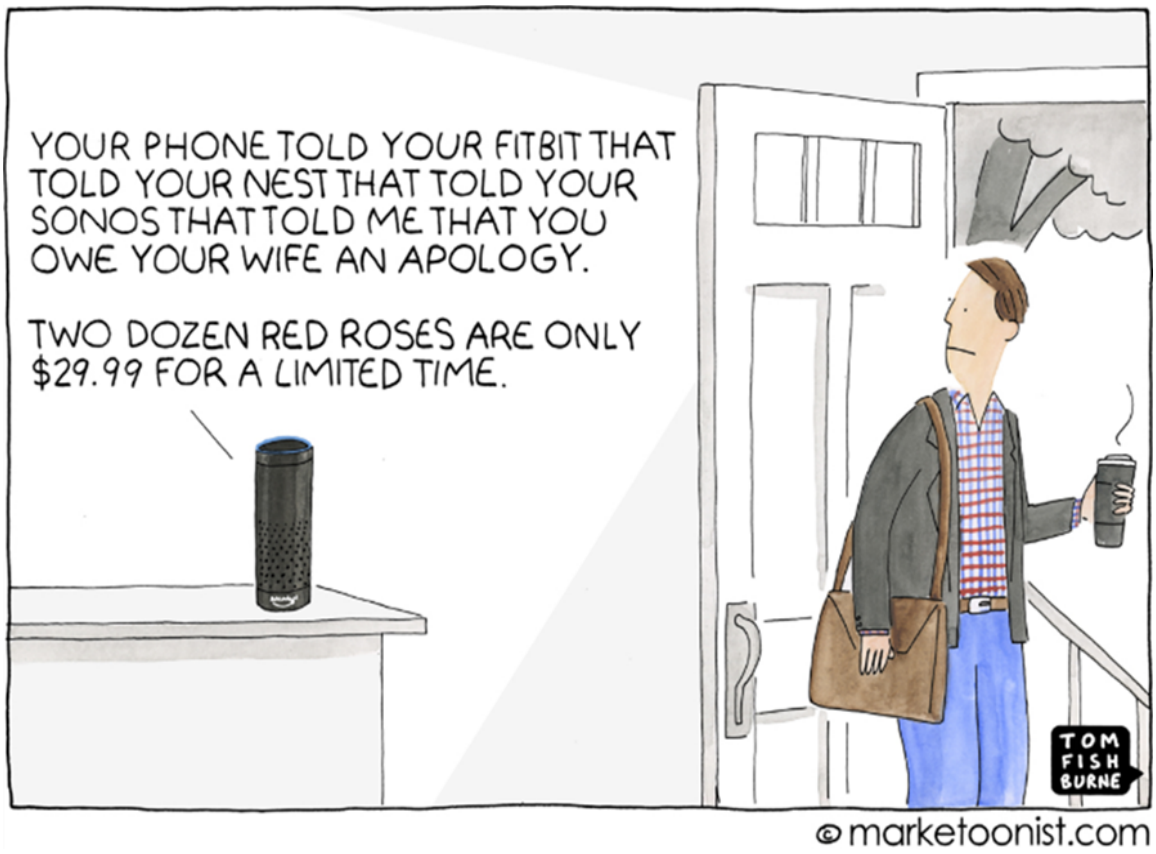
- **6:30 AM** – Arvind woke up for an important meeting but realized that a crash on I-280 meant he would reach late → **AI would have predicted his new commute time based on current conditions and his departure time and woken him up earlier to make his meeting.**
- **6:45 AM** – Arvind takes his daily dose of vitamins but he isn't taking enough for the vitamin D deficiency he has → **His health bracelet would**

**have detected lower vitamin D levels and doled out an extra dose of VItamin D to compensate.**

- **7:00 AM** – Arvind sits down for breakfast but realizes the milk has expired and has turned sour → **Cameras with AI in his fridge would have detected the expiration date on the gallon jug and automatically ordered a new jug.**
- **11:45 AM** – A UPS driver leaves a package on Arvind's porch but 15 mins later it is stolen by an intruder. He had turned off his camera motion notifications since it tripped unnecessarily very often and once cost him $200 because the police were called out → **AI would have detected Arvind's UPS driver and opened the garage door for the UPS driver to leave the package in the garage. When the intruder approached the house, AI would have detected an unknown person much more accurately and made notifications more meaningful to Arvind.**
- **1:00 PM** – Arvind's older parent falls while climbing down the stairs and cannot get to a phone to call for help → **In home cameras with AI would have detected the fall and setup a call with Arvind on speaker phone so he could communicate with his parent and provide assistance. If the parent's bracelet detects life threatening changes to body vitals, it would call emergency services automatically and provide them with the information.**
- **3:00 PM** – Arvind's kids return from school but they forgot their keys at school → **AI enabled cameras would recognize yours kids and unlock the door for them**
- **6:00 PM** – Arvind wanted a healthy salmon dinner but he doesn't have any Salmon at home → **AI recommendation systems would have predicted what he would have liked to eat and ordered it from freshcart in the proportions he usually eat**
- **9:00 PM** – Kids in bed and Arvind jumps on the scale on realize he has put on 20 pounds → **AI predictive algorithms would have taken into account his current weight, time of year, his activity level and signed him up for a spin class 3 days a week**

- **11:00 PM** – Arvind is in bed but can’t get himself to fall asleep for a big work day tomorrow → **AI would detect his restlessness and play some meditation music based on its recommendation engine to lull him to sleep**

***Home IoT + AI*** *will enable the home to evolve from a dwelling to a caretaker.*



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