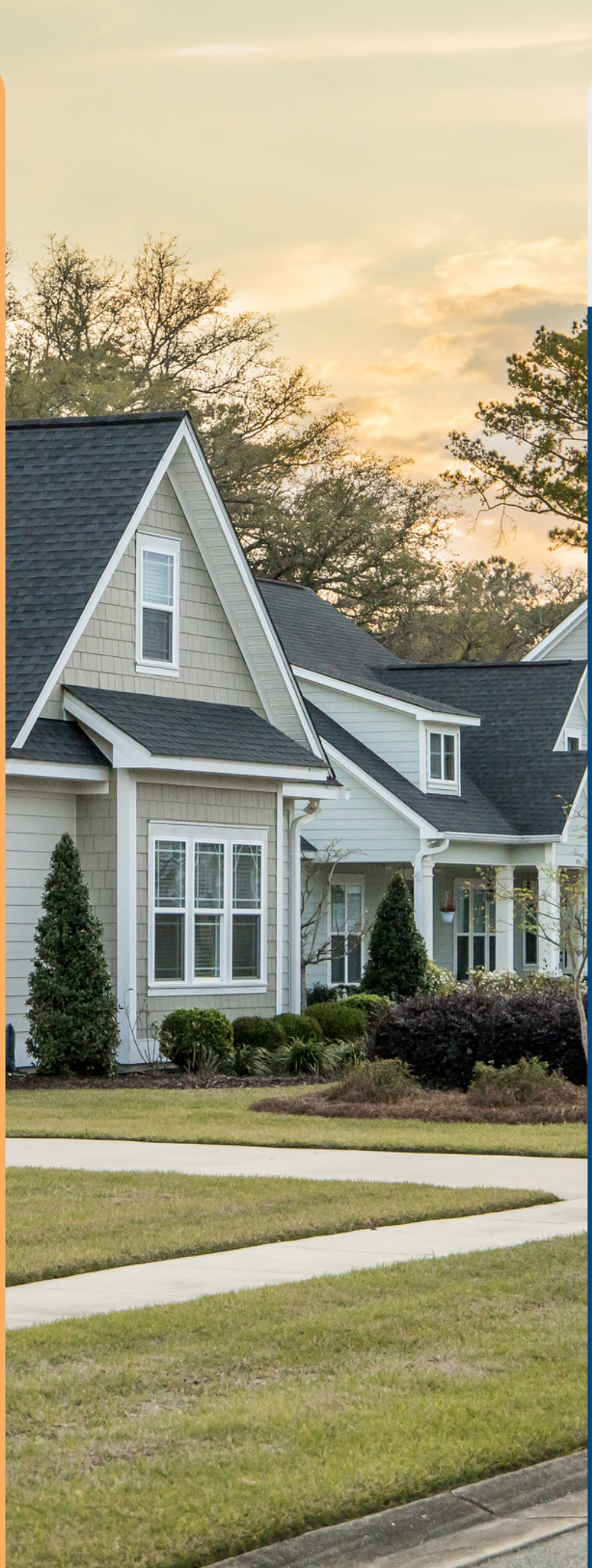

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Predictive Maintenance for Homeowners

Unlocking the Promise of the Smart Home

by Alexander Linn

Predictive Maintenance for Homeowners

Contents

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Abstract

Predictive maintenance is now a possible solution for single-family homes. Advancements in cloud computing and the proliferation of connected devices enabled commercial buildings to transform their operations from reactive and manual to proactive and automated. To accomplish this predictive maintenance, operators deployed Internet of Things sensors and developed powerful analytics utilizing machine learning and other advanced techniques. The adoption of predictive maintenance in commercial buildings **reduced the costs of the underlying technology and created the opportunity to apply predictive maintenance technology to single-family homes.**

Predictive maintenance presents a major opportunity for individual homeowners, service providers, and communities overall. Homeowners can save time and money and reduce their carbon footprint through smarter decisions and data-driven home improvement projects. Homeowners can also address the health issues caused by poor indoor air quality. Service providers can benefit from smarter, higher value and more efficient methods of serving homes. Finally, as a result of predictive maintenance, communities overall can benefit from economic development, lower pollution and improved quality of life.

Many useful connected products have been developed. However, to date, connected products are mostly designed for entertainment, automation and security. Could this technology and the data from connected devices be used to enable predictive maintenance for homes?

For example, Sam, a homeowner in Alabama, recently installed temperature and humidity sensors in her attic and crawl space. Problems that originate from unseen areas of the home are notorious for sneaking up on homeowners. These problems often materialize at the very worst time. By using real data collected from connected devices, Sam was able to predict that the installation of humidity control in the crawl space and a radiant barrier under the roof was necessary to avoid future problems. These upgrades not only saved Sam money on her energy bill and improved the comfort level in her home but also stopped mold growth that was slowly progressing without Sam's knowledge. This home improvement project came with a high return on investment. It extended the life of the home by preventing rot and mold growth on the subfloor. As a result, Sam prevented the development of indoor air quality problems in her home. Indoor air quality problems often lead to respiratory issues such as asthma attacks, allergies and sinus infections. Finally, Sam saved several thousand dollars by utilizing real data to focus on the most impactful projects first.

The adoption of predictive maintenance will lead to safer, more reliable and more efficient homes.

Meet the Homeowner

- On the path to financial independence!
- Working to build equity in the home
- Creating a safe environment for her family
- Managing expenses and saving energy
- Does not have a lot of spare cash in the bank account
- Not an expert in how the systems are supposed to work
- Not always home to monitor

for privacy reasons the image of the person and home featured here are not of the actual home or owner

Unlocking Real Value

Homeowners and their providers should look to predictive maintenance to improve the homeownership experience and achieve better outcomes. The whole community will benefit!

Reduce cost of homeownership

Owning a home is the highest expense in a person's life. According to the U.S. Bureau of Labor, Homeowners on average spend 11% of their monthly budget, $7,068 per year, on utilities and household operational costs. Today homes are maintained on a reactionary basis ("break-fix") without access to real data or insights about how your home is operating. Proven results of predictive maintenance in the commercial and industrial setting demonstrate that a significant portion of this expense is wasted on inefficient home maintenance.

Reduce carbon footprint

According to the U.S. Environmental Protection Agency, the average home emits about 5.906 metric tons of carbon each year. Consider the large number of service trucks on the road and old appliances in landfills. Using proper home performance data, the average home can improve energy efficiency by 30% according to the HERS network which has rated over 3 million homes for energy efficiency.

Save time

Homeowners spend an estimated 60 hours per year on home maintenance-related tasks – often at very inconvenient times. That amounts to nearly 1.5 working weeks. It is now possible to reduce that with good data and analysis, plus an active link to the homeowners' service provider(s) providing them the information to better serve the homeowner.

Plan for big expenses

According to BankRate, the average homeowner does not have $1,000 to cover an unexpected expense. Often, a major expense like a broken AC unit can put a family under major financial stress. Real data can be used to predict the remaining lifespan for your equipment and help you plan for the upcoming expense while also reducing the expense. Real data can also help to predict and prevent issues that lead to large expenses.

Avoid health issues

Our homes should not be making us sick. Unfortunately, many homeowners are unknowingly living in homes infested with mold, dust mites and other health risks that can cause asthma attacks, sinus infections and other serious health consequences. It's estimated that the US spends $84 billion on economic losses related to the Asthma epidemic annually.

Preserve home value

Unresolved home maintenance can lead to major damage and difficulty selling a home. Good data about the home's maintenance history and operating performance will give peace of mind to a new buyer. In the all too frequent worst scenario, homeowners attempt to sell their home, but it fails to pass inspection because of some major maintenance issue that the homeowner did not even know about. These problems can cost tens of thousands of dollars that homeowners do not have access to which forces the homeowner to sell below market value.

Mitigate effects of severe weather

Increasingly homes are hit by severe weather which causes increased demand putting a strain on the systems in the home. As a result, major breakdowns and big expenses follow severe storms.

Increase comfort and convenience

Properly operated homes are more comfortable and easier to maintain and service.

Get peace of mind

Homeowners should not live in fear of unknown or unmaintained issues, or with nasty surprises that could go wrong.

Identify weatherization needs

The lowest cost, cleanest way to save energy is to not use it. Currently, we waste a ton of energy trying to heat and cool homes that are not properly weatherized. The problem is knowing what weatherization improvement to make and how valuable it will be to make it. It's possible to waste a great deal of money weatherizing a home without access to insights from the data. According to NAIMA, 90% of homes need insulation.

More efficient upgrades

The average home needs tens of thousands of dollars of upgrades to achieve modern standards! Upgrades can be prioritized based on a thorough analysis of the impact to the home examining factors like the severity or urgency which with an issue should be addressed. This means upgrades overall will be lower cost and more effective because homes can utilize accurate data about how the home systems are performing before and after upgrades. Predictive maintenance makes home upgrades much more self-funding – radically increasing the potential number of jobs and annual upgrade sales. This in turn facilitates a more rapid transformation to a self-sustaining economy with a much lower carbon footprint.

Participate in local economic development

As homes get upgraded, jobs get created for small businesses. Furthermore, as homeowners shift their time and money from burdensome home maintenance and operations, they can invest in developing their careers and helping their families to grow. As indoor air quality and other health risks are mitigated families will spend less time and money dealing with doctor visits and sick days. The health issues are in many cases much more prevalent among the low-income and minority populations.

Improve interactions with providers

Utilities, insurance, maintenance pros, and anyone taking care of a home can do a better job with the help of predictive maintenance technologies that monitor home performance. Traditionally these businesses have had little access to information about what is going on inside the homes or behind the walls. Consequently, the relationship is a challenge to manage and many issues are reactive and unpleasant.

Emerging Technologies Enable New Possibilities in the Marketplace

In recent years, emerging technologies enabled major breakthroughs in predictive maintenance. Machine learning algorithms unlocked the promise of artificial intelligence. Cloud computing and mobile technologies transformed everything as they enabled software to truly eat the world. Before these advances, predictive home maintenance was not possible. These technologies can now be combined with low-cost sensors and controls to make home systems intelligent enough to analyze their own performance and report on their own needs.

Despite the abundance of low-cost sensors on the market, many homeowners do not have a single sensor or IoT-enabled appliance in their homes! However, a major tipping point in the market occurred when Amazon acquired Ring and Honeywell spun out Resideo in 2018. Then in 2020, Vivint went public. These milestones followed a decade of significant efforts by many big companies and startups to build the device layer. For example, Google's acquisition of Nest in 2013. Since then, homeowners have grown to rely on the smart home for many daily needs from turning the lights on to locking their front doors. Today, the global smart home market has reached $40 billion and is projected to grow rapidly as it becomes easier and less expensive to deploy IoT devices every day. Now leaders like Stacy IoT are calling for a new era for the Smart Home to provide more meaningful value.

Technology Trends

The proliferation of smart home devices and the declining cost of the underlying technologies.

- The average price of an Internet of Things (IoT) sensor has declined from $1.30 in 2004 to $0.44 in 2018, according to Microsoft's "2019 Manufacturing Trends" report.
    - Average costs of industrial Internet of Things (IoT) sensors from 2004 to 2020
- Smart Home Technology Hits 69% Penetration in U.S. 09/30/2019 The majority (69%) of U.S. **households** now own at least one **smart home device**, based on a new study. That translates to 83 million **households** and of those, 18% or 22 million **homes**, own more than one **smart home** product, according to the study by the Consumer Technology Association(CTA).
- Forecast that there will be close to 2.7 billion installed smart home devices in the United States by 2023

Artificial Intelligence Use Cases

Sensor-enabled devices – internet-connected devices enable the collection of data that can provide insights about the operations of a home. These devices can even be controlled remotely.

Networking – Connected devices can be networked together to create a more robust understanding of the home's performance.

Predict maintenance needs – it's much less expensive to operate your house if you can predict issues ahead of time. Some issues can be solved directly from the homeowner's mobile phone without requiring you to be home. If the homeowner does need to attend to maintenance it should be planned. For example, oftentimes homeowners use dehumidifiers. The filters need to be changed regularly, and if they get dirty faster than expected, they should be replaced to preserve the life and efficiency of the dehumidifier. Ultimately, this capability helps homeowners reduce the time they are interrupted for equipment service and it helps to reduce the number of service truck visits needed which radically reduces the carbon emissions of the entire industry.

Identify anomalies - techniques can be applied to big data captured from equipment to identify abnormal behavior that might not otherwise be noticed by an occupant. It's possible to use this kind of analysis to identify trends and issues in real-time. For example, imagine a homeowner's AC unit is working harder than usual. It used to take 15 minutes to cool a home 5 degrees, now it takes 32 minutes. Would a homeowner notice this? Would a homeowner know what it might mean?

Analyze outcomes - homeowners ultimately care about certain outcomes. If a homeowner cares about their home being safe from the risk of mold, the outcome would be preventing mold damage. Outcomes homeowners tend to care about are safety, reliability, economic efficiency, energy efficiency, maintenance, and comfort. Using regression techniques, it is possible to predict those outcomes before they happen and preemptively take actions to reduce the risk of a bad outcome!

Filter alerts for relevance - People are growing increasingly fatigued with alerts and being tasked with identifying the relevant alerts from spam. Machine learning can be used to prioritize these alerts and help the homeowner focus on the most important issues.

Recommend next best action – The alerts themselves can cease to be just an alarm and instead include the significance of the information and what to do about it – including automated notification of the desired vendors. An industry thought leader, Stacy IoT, recently said – "why does a fitness tracker tell you how many steps you've taken, why doesn't it tell you how many more steps you need to take to lose the amount of weight you said is your goal?"

Optimize everything - providers, energy use, time spent, capital requirements and operating costs can all be optimized with real-time data.

Remaining Technology and Market Barriers to Address

Homeowners are beginning to realize that they have been underserved with home management technology. Their cars are now driving themselves and their packages arrive with the push of a button but homeowners still lack visibility into, or any data about, the performance of the critical infrastructure of their homes.

Unfortunately, the homeowner finds that the companies that are connecting devices in their homes are not yet delivering predictive maintenance. Inexpensive connected devices enable data collection in mass from homes, and the rapid progress of machine learning techniques enables the discovery, interpretation and surfacing of insights hidden within the data collected. Yet this data is oftentimes not even accessible to the homeowner.

Many great companies are already working on predictive maintenance technologies for homeowners. Nest, Ecobee, and Honeywell have all begun to send alerts from their thermostats. Flo, Stream Labs, Leaksmart and others have developed great water shut off valve technology. Aeotec, Samsung, Ring, Vivint and others have leak detectors, temperature and even humidity sensors in the market. **However, for homeowners to fully unlock this potential, they need a home management platform capable of predictive maintenance and provider management.**

1. Devices need to be installed and made accessible to homeowners
2. Manufacturers need to continue on the path to enable the homeowner to integrate their devices and share their data
3. The ecosystem around homeowners should be networked together for increased efficiencies and capabilities
4. Solutions should be delivered so that they serve the homeowners' best interests
5. Trust through privacy and security is paramount to successfully delivering solutions to homeowners

A Roadmap to Predictive Maintenance for Homes

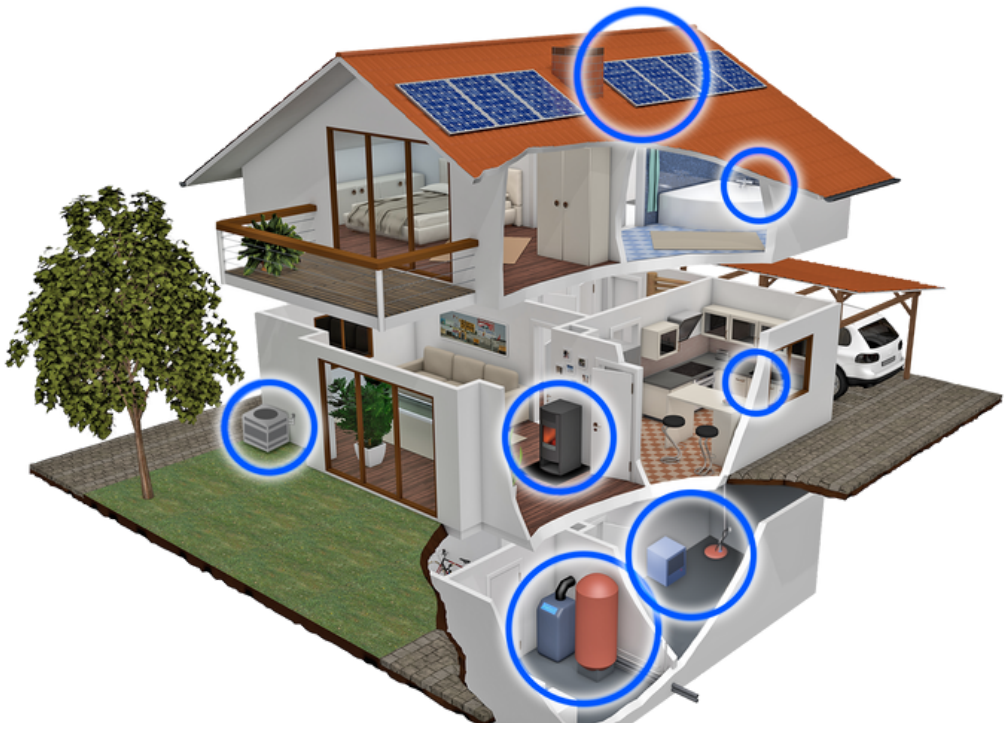
Homeowners are heroes in the eyes of the economy. Operating a single-family home is like running a small business. Homeowners who carefully invest in their home and its operation find that their home increases in value and the costs in dollars, hassle and carbon emissions are much less!

Many homeowners are already pushing the envelope of what is possible with the connected devices in the home to help operate and maintain it more efficiently. Here is an overview of how predictive maintenance can be applied to homes.

1. Determine the Use Cases
2. Select the Right Sensors
3. Connect to the Home Provider Ecosystem
4. Seeks an Integrated and Intelligent Experience

Determine the Use Cases

Homes have many critical systems. When determining which systems you should connect and monitor, consider which system is the **most expensive, biggest hassle, and biggest energy user**. Think about the solutions that can benefit the homeowner the most in terms of air quality, comfort, water control or energy savings.



Uninhabited Spaces

Attic	Basement
Attic fan	Crawl space
Roof	Bathroom
Media room	Pool house

Uninhabited Spaces

Thermostat	Compressor
Air handler	Heat pump
Ducts	Furnace
Coil	Dehumidifier
Humidifier	Condensation pumps

Heating ventilation and air conditioning systems include many components that should be monitored for performance.

Water Control

Sump pumps	Solar water heater
Water shut off valves	Pool/spa
Water heater	Water meter
Water filtration	Water softener

Appliances

Washing machine	Wine fridge
Dishwasher	Refrigerator
Ice maker	Frezer

Air Quality

Radon	VOC
CO2	Humidity

Power Generation & Storage

Generator	Backup battery
Solar photovoltaic	Geothermal

Sewage

Sewer line	Septic pumps

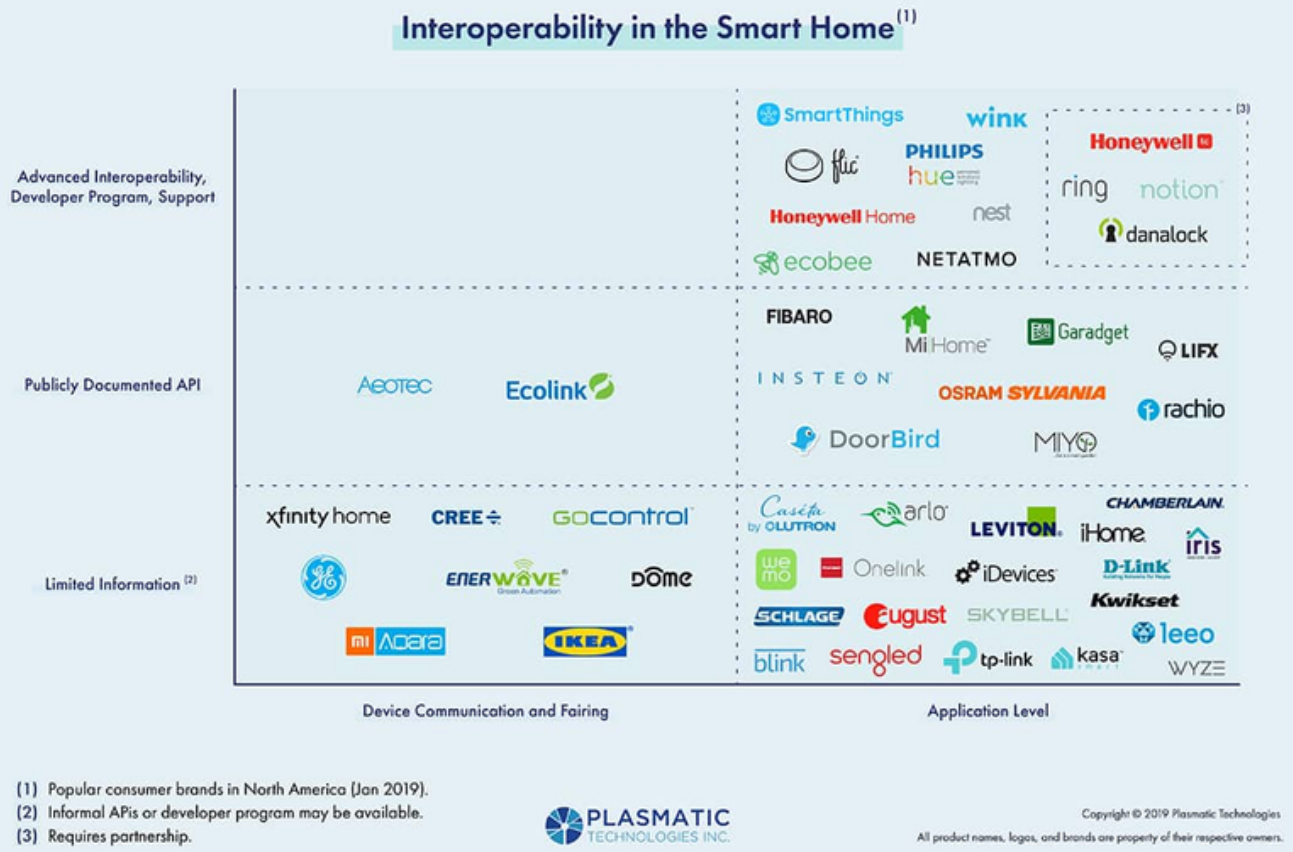
Select the Right Sensors

Once you have selected the use cases, now you need to determine how to connect them to begin analyzing the data.

As a homeowner, there are many choices for hardware ecosystems. Increasingly, these systems are either interoperable or open for integration. Homeowners should ask the manufacturer if they are open to integrations.

Leading companies like Amazon, Google and Samsung are building vast ecosystems. Providers like Vivint, Comcast, Alarm.com and ADT are bringing these services to homeowners. New innovative device makers like AirThings, Awair, Ecobee, and others are bringing connectivity to homes.

Manufacturers like Aprilaire, Rheem, Emmerson, and others are developing connected appliances that are already outfitted with sensors.



https://www.iotforall.com/smart-home-interoperability-key-hurdles

Connect to the Home Provider Ecosystem

New value can be created by networking providers together. A next generation ecosystem is being built around the home.

This is about creating the win-win-win as these new technologies network together a broad and currently fragmented ecosystem that supports the home.

Provider	**Contribution**	**Benefit**
Insurance	Many leading insurance companies are already making big plays with smart home strategies. In particular with leak detection and water shut off valves.	Risks can be identified that were otherwise difficult to prevent allowing insurers to reduce their loss ratios. New systems can create additional points of engagement and loyalty allowing insurers to build new value for their customers through connected services. Insurance providers are in a perfect position to offer discounts and subsidize the costs of sensors.

Provider	Contribution	Benefit
Utilities	Utilities can often subsidize hardware that promotes efficiency and this will drive increased rate of adoption for the needed hardware infrastructure.	Trends like urbanization, distributed generation, and extreme weather all make managing a power grid more complicated! As homeowners adopt predictive maintenance technology, this will allow dynamic load management by the grid allowing the utility to optimize the grid and reduce the need for peak generation.
Home maintenance & repair providers	These experts at maintaining homes can help to sell and install predictive maintenance solutions.	There are over 500,000 small businesses in the United States that provide contract services to homes. This will help these businesses operate more efficiently and create stickier relationships with their customers.
Warranty providers	Warrantee companies can offer discounts and market predictive maintenance solutions to homeowners.	With improved data, risks can be better managed and ultimately payouts can be reduced. This proactive relationship will lead to more satisfied, loyal customers.
Appliance manufacturers	Appliances can not only generate alerts based on data from their on-board sensors, they can also be integrated to other products so the homeowner can achieve a complete solution.	Enhance customer relationships and value delivered while maintaining customer contact. This presents an opportunity to grow aftermarket services like warranties and part replacements. Even potentially deliver their appliance “as-a-service.”

Provider	Contribution	Benefit
Smart home device makers	Smart home devices provide new data that unlocks new value for customers. This value can be expanded through integrations that allow homeowners to configure the solutions that they value most.	Sell more devices and increase the lifetime value of a customer.
Builders	Predictive maintenance solutions can be deployed at the time of construction.	Increase consumer value and satisfaction. Differentiated product offering.
Government	Government can play a major role by providing subsidies and incentives to help homeowners upgrade their homes.	Precise knowledge of the home and its systems will allow the delivery of more effective and cost-efficient programs.
Home security providers	Seek partnerships and expand their offering to help their customers access predictive maintenance solutions.	Eventually, all of the systems of the home will be linked to give the homeowner a whole-home solution. As this happens, Security providers can expand their revenue potential and customer loyalty through new added value.
Landlords & property managers	Can install and adopt predictive maintenance in the homes they manage.	This technology will help operate, maintain and monitor vast collections of properties across the U.S. reducing risks and costs while streamlining management.

Connect to the Home Provider Ecosystem

New value can be created by networking providers together. A next generation ecosystem is being built around the home.

Conclusion

Let's build this now!

Predictive maintenance holds the potential to transform homeownership, and now is the time to drive adoption. The community should work together to deliver predictive maintenance for homeowners. Homeowners who can adopt solutions for their homes should. Technology providers should double down on efforts to deliver the solutions. Policy-makers and community leaders need to look for ways to use these technologies to automate home maintenance to provide value to their constituents. The opportunity is enormous to save money, reduce carbon emissions, prevent health issues and help families live with peace of mind.

Adopting predictive maintenance in homes is one of the, if not the, most impactful economic development initiatives that can be undertaken in the United States because it will promote social justice and accelerate the transition to a sustainable economy.

As Marc Andreessen recently said, "IT'S TIME TO BUILD." Let's work together as a tech and home services community to help homeowners – and grow our businesses.

This is a winning proposition for everyone.

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Published Feb 22, 2021

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