THERE'S NO PLACE LIKE THE SMART HOME

INTEL'S SMART HOME VISION

SUMMARY

Due to its diversity, fragmentation and inherently consumer-driven nature, the smart home represents one of the most challenging but potentially rewarding market opportunities in the history of the high-tech area. While the global unit and revenue size of the smart home market is large and is expected to grow at an accelerated rate over the next several years (reaching $100B in 2020)[1], the severe multi-player nature of the category will not likely yield one or two dominant winners, but numerous companies who solve specific tangible problems in the smart home and make consumers' lives more productive.

Connectivity trends in the consumer broadband segment have created a welcome atmosphere for aspiring smart home users. Fixed broadband subscribers have grown in the United States from ~73M users in 1Q10 to over 95M users at the end of 4Q17.[2] The proliferation of Internet-connected mobile and IoT devices, as well as legacy desktop and notebook products, in today's homes has pushed consumers to demand "utility grade" bandwidth (with accompanying robust security) that apps and smart home services require for an exceptional consumer experience. This phenomenon is certainly a manifestation of Nielsen's Law, which observes that as more bandwidth becomes available, consumers will find new ways to use it --- though some are not always obvious.[3]

At an ecosystem level, the essential problem with today's smart home is largely a "plumbing" problem: IoT devices in the home demand 24 X 7 reliable access to the Internet, yet the infrastructure to provide the Internet "pipe" to consumers' homes is inconsistent from a high-speed bandwidth standpoint, geographically uneven across the United States and mostly offers asymmetrical speeds. In addition, the distribution of high-speed Internet access in the home is sub-optimized, as today's routers often do not guarantee the superior quality of service (QOS) that today's smart home requires, not to mention the high number of smart mobile devices used simultaneously in the average home. Finally, digital assistant-based products with integrated Amazon Alexa, Google Assistant and Apple Siri functionality are becoming a necessary "must have" ingredient

[1] https://www.juniperresearch.com/press/press-releases/smart-home-revenues-to-reach-$100-billion-by-2020

[2] https://www.statista.com/statistics/217938/number-of-us-broadband-internet-subscribers/

[3] https://www.nngroup.com/articles/law-of-bandwidth/

in every smart home, and their consumer value will only grow as artificial intelligence (AI) and machine learning enhance their usefulness and implementation over the next several years.

This paper examines Intel's value proposition and strategy in context with the above problem statement. Companies that can provide technology and value that addresses this challenge are likely to participate in the revenue tailwind of the growth that is currently occurring in the smart home market. Like all bets in the technology field, winners and losers are largely determined by those companies that have a strong value proposition for both consumers and partners, take aggressive but educated risks, leverage their strengths and (perhaps most importantly) stay committed to their vision.

MARKET SIZING AND USAGE MODELS

Due to its size and (especially) fragmented orientation from a diversity of devices standpoint, measuring the size of the "smart home" market could not be unreasonably compared to calculating the amount of water in an Olympic pool using a teaspoon. One useful approach is to choose two popular device categories as smart home market proxies that are currently exploring rapid growth and indicate consumer acceptance. Using that filter, two reasonable product segment areas would be:

- Smart speakers/personal digital assistants (prominent examples include Amazon Alexa and Google Assistant-based speakers, as well as solutions from Apple and Microsoft, among others)
- Home modems, routers and gateways (cable/DSL/fiber/retail-based solutions that are often packaged as Customer-Premise Equipment by cable, telco and broadband service providers), further spurred by the appearance of 5G fixed wireless access on the scene in 2018 and beyond.

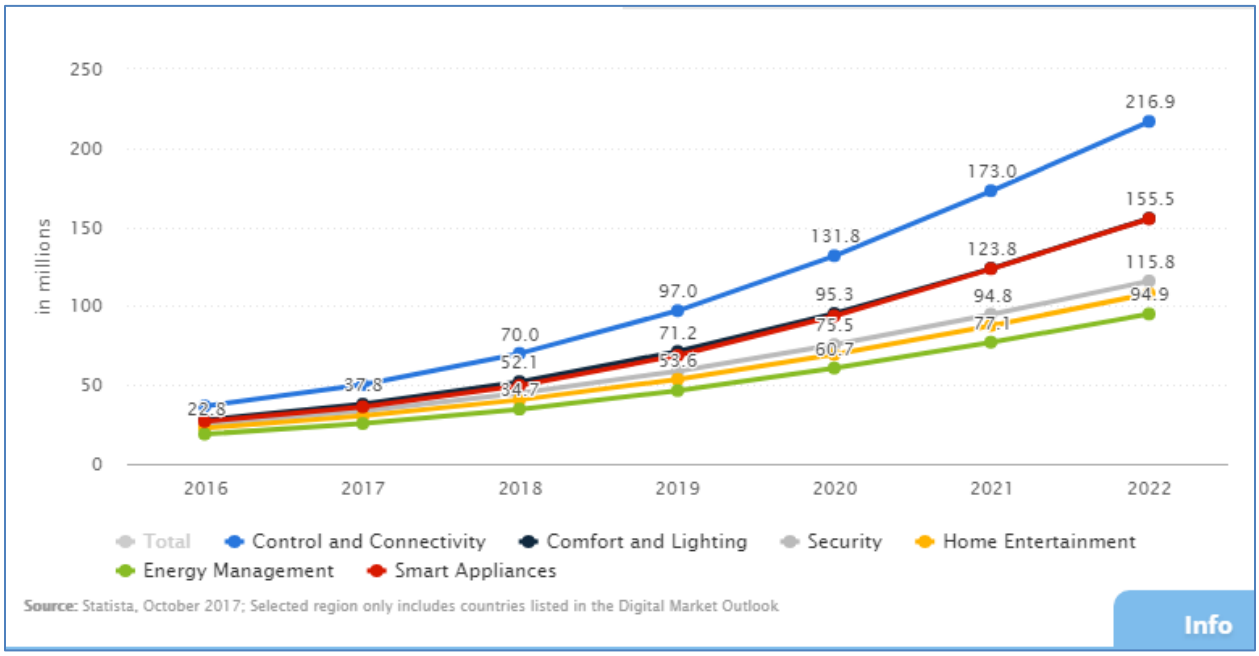
The announcement of the first Amazon Alexa-based speaker Echo in November 2014 ushered in the era of "ambient computing." Google followed with its Google Home Smart Speaker in November 2016. Despite privacy and security concerns about these devices, they are immensely popular and are poised for dramatic growth over the next several years.

For many consumers, the usage models embodied with these digital assistants represent the very heart of the "smart home." Using voice interaction, a digital assistant can enable music playback, record to-do lists, set alarms, stream podcasts, play audiobooks, provide weather and traffic updates, and report real-time news. Amazon has been particularly

aggressive with expanding the capabilities of Alexa by installing "skills" — additional functionality developed by third-party vendors that enable voice management of popular smart home devices like thermostats, lights, home security and robot vacuums, among others. Typical mainstream consumers see "voice automation" of mundane, repetitious household duties as the true manifestation of the smart home and its productivity promise.

For these reasons, smart speakers, as well as the growing "personal assistants" category, are considered the "royalty" of consumer technology because of the home automation and "knowledge base" convenience they have come to personify with consumers. In 2018, smart speaker shipments (predominantly solutions with Amazon Alexa or Google Assistant functionality) are expected to grow more than 75 percent and reach 56.3M units worldwide in 2018, up from 32M in 2017.[4] In fact, as the below Statista chart indicates, all major smart home device shipments worldwide are dramatically increasing, from 158.5M units in 2016 to 846.3M units in 2022:

FIGURE 1: WORLDWIDE SMART HOME OPPORTUNITY (UNITS): 2016-2022



Source: Statista.com (https://www.statista.com/outlook/279/100/smart-home/worldwide#market-revenue)

More evidence of the tremendous growth in high-speed broadband connections desired by consumers can be found in a publicly available market forecast from the International

[4] http://www.zdnet.com/article/smart-speakers-are-now-the-fastest-growing-consumer-technology/

Telecommunication Union (ITU). If you assume that fixed-broadband subscribers tend to refresh their home gateway every 6 years or so, and consider ITU's global forecast through just 2017[5], that would equate to more than 220 million Customer-Based Equipment (CPE) units per year to support the nearly 980 million fixed-broadband subscribers around the world.

From a home wireless connectivity standpoint, consumer router purchase behavior appears to indicate they understand the importance of having high-performance bandwidth throughout the home. Usage model drivers like video conferencing, OTT/Over the Top (e.g. Netflix/Hulu) and OTA/Over the Air (e.g. cord cutting) content streaming in the home, home monitoring/security and online gaming (just to mention a few) have validated a "build it and they will come" phenomenon. Specifically, mesh-based routers have quickly become the fastest growing networking products category (especially in the retail consumer segment), expected to reach forecasted sales of $11.3B by 2025.[6] With mesh-optimized products from established companies such as Eero, Plume, Netgear (Orbi) and D-Link growing in popularity, mesh technology's capability to enable more consistently available bandwidth throughout large homes (and even outdoors) is distinctly appealing to consumers with smart home aspirations on their minds.

INTEL'S PRIOR EFFORTS IN THE SMART HOME

Intel has dramatically evolved in its thinking and approach to the smart home over the past 10 years. In previous years, Intel's digital home efforts essentially centered around the PC, as Moore's Law was in full effect and it was relatively easy to convince consumers to upgrade their PC to the latest processor (and latest version of Microsoft Windows). The consumer PC lifecycle was less than 18 months and Intel's business model performed exactly as planned with PC OEMs taking advantage of huge refresh opportunities every time Microsoft announced a new version of Windows (which conveniently coincided, most of the time, with a new, faster Intel microprocessor offering).

Among the key suppliers in the technology space, Intel was not alone in its thinking that the PC should be at the center of the digital home. In 2002, Microsoft famously announced its Media Center offering, creating a 10-foot multimedia experience in the living room to facilitate the consumption of video, music and television. This led to most of the major OEMs introducing desktop form factors that were designed to be placed in the living room entertainment center of a home. Not to be outdone, in 2006, Intel

[5] https://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2017/ITU_Key_2005-2017_ICT_data.xls
[6] https://www.grandviewresearch.com/press-release/global-wireless-mesh-network-wmn-market

announced its Viiv™ platform that was focused on sharing audio, image and video capabilities throughout the home, expressly crafted to support the view that consumers' entertainment experience would likely be headquartered in the living room.

FIGURE 2: INTEL VIIV™

Source: Intel Corporation presentation at WinHEC 2006

The PC-centric view of the world did not materialize in the ensuing years due to a variety of factors, but primarily due to the rise of the smart phone and tablet as consumer computing evolved into a mobile phenomenon. Interestingly, it could be argued that Intel's past digital home strategy anticipated some of the popular usage models that consumers are engaged in today, driven by exponentially more advanced computing technologies. Intel's latest strategy has transitioned to a "smart home" focus largely because today's consumer computing experience changed as a result of usage models that require pervasive broadband connectivity and multiple connected devices in the home. Moreover, Intel's smart home strategy recognizes that today's computing experience is incredibly more personal and mobile in nature and will likely continue to be so in ways that cannot

even be contemplated as bandwidth speeds get faster and ubiquitous device connectivity becomes a reality.

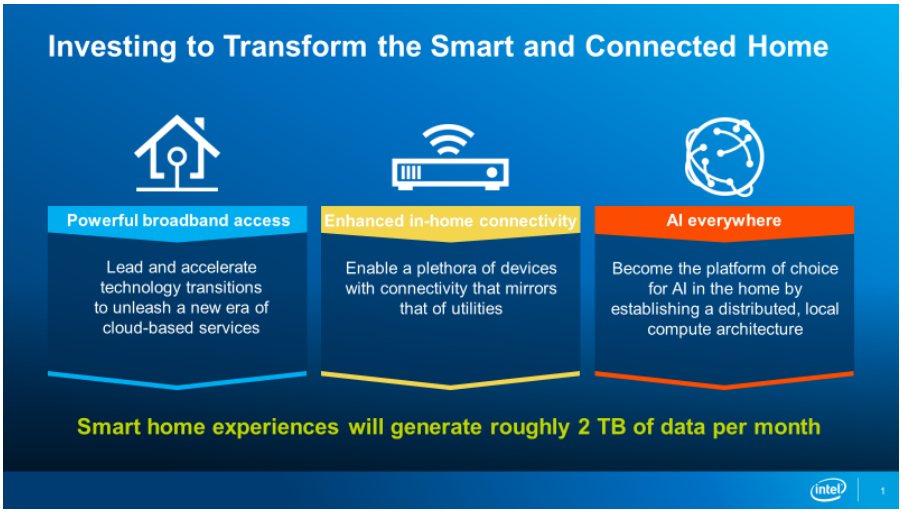
OVERVIEW OF INTEL'S MACRO STRATEGY

Intel has not announced a formal connected home strategy in a traditional manner. Rather, it has announced several specific complementary initiatives that logically fit under a strategic "umbrella" framework. We believe Intel may have done this intentionally. Intel's dominance and strength in the PC ecosystem doesn't yet transfer to the smart home/home connectivity space. Its approach, therefore, must be more collaborative. There are critical partners from whom it will require assistance and expertise to execute its long-term objectives in the home.

Despite taking a more collaborative approach, from a sheer size, scale and industry clout standpoint, it is difficult to argue that Intel is not one of the few companies with the potential to bring a sense of order to the connected home and exploit its potential. While some might perceive this as counterproductive to its efforts, it is important to point out that Intel's executive smart home team efforts appear to be highly focused on putting consumers in control of their smart home destiny and making sense out of the chaos that characterizes the fractured composition of today's smart home landscape.

Intel's connected home approach focuses on the following pillars and market segments as shown in Figure 3.

FIGURE 3: INTEL'S CONNECTED HOME APPROACH



Source: Intel Corporation

FIGURE 4: INTEL'S FOCUS FOR THE SMART AND CONNECTED HOME

Source: Intel Corporation

INTEL IS INVESTING IN INDUSTRIAL-STRENGTH BROADBAND ACCESS TO THE HOME

Smart home applications like video streaming (OTT/Over the Top), home automation, home security, cord cutting (OTA/Over The Air), gaming and video conferencing (just to name a few) are placing a tremendous burden on today's bandwidth pipeline into the home.

Given its strong enterprise and data center orientation, it's not surprising to see that Intel is focusing on this problem from a data point of view, estimating that smart home household experiences will generate 67GB of data requirements per day. On a yearly basis, this could be as much as 25TB of data per year…a huge number considering this is based just on IoT device consumption.

Intel takes a strictly agnostic view of the various pipes that facilitate Internet bandwidth into the home. Intel's family of AnyWAN™ and Puma™ SOCs are positioned to address today's DSL, fiber and cable high-end gateways, future 5G gateways and routers.

Intel's hallmark has always been about ease of integration and development, and their AnyWAN offerings enable the reuse of existing software across a wide range of applications, a huge benefit for equipment and service providers to maximize and project the value of their investments.

Consistent with Nielsen's Law that states that broadband bandwidth tends to grow at 50 percent per year, Intel has been leading the charge by fully embracing new standards for broadband access as the broadband market begins to increasingly offer multi-gigabit speeds, including DOCSIS 3.1, Full Duplex DOCSIS 3.1, G.fast, 10G PON and 5G millimeter wave. Intel explicitly believes this significant increase in broadband bandwidth over the next 12 to 36 months will conjure up new consumer usage models that cannot be contemplated at this time.[7]

INTEL IS INVESTING TO DRIVE POWERFUL BROADBAND INSIDE THE HOME

Intel has a robust, enterprise-like view of connectivity in the home, meaning that it believes the smart home value proposition breaks down if consumers don't have robust and reliable, dependable connectivity to manage all critical functions in the home (e.g. home security, thermostat, home monitoring, and other usage models requiring robust device connectivity).

While cable and telco providers tend to have significantly longer lifecycles for gateways and routers that they lease to consumers, the consumer retail market for routers typically transitions much more rapidly. Mesh-based routers are a great example of this phenomenon and they now represent more than 22 percent of total router units in the U.S. retail market, a growth improvement of 37 percent from mesh router unit share in early 2017.

For its part, Intel currently offers Wi-Fi chipsets for home connectivity and plans to extend that portfolio with 802.11ax chipsets in the future. The 802.11ax-based chipsets are designed to take full advantage of the following features: 40 percent higher peak data rates, 4X better average throughput in dense home environments, and 4X increase in network efficiency. Intel's 802.11ax chipsets also will be capable of supporting a very large number of devices simultaneously (increasingly important as homes become more "dense" with connected devices) and will be optimized for various packet sizes, an efficiency advantage since there tend to be a mix of apps and workloads accessing the home network.

INTEL ACKNOWLEDGES IT'S NOW AN "AI EVERYWHERE" WORLD

Intel is looking into its crystal ball and is making big bets that machine learning and artificial intelligence (AI) are going to become much more dramatic elements in tomorrow's connected home. Aided by the growing appeal of voice and ambient

[7] NPD, Stephen Baker Interview, March 2018

computing as the preferred interface to manage a smart home, Intel is investing in capabilities that will help products anticipate consumer behavior and proactively recommend courses of action, something that we only see a glimpse of in today's smart home products.

Intel's proof point supporting this commitment to "AI Everywhere" is its partnership with Amazon, announced in October 2017. Collaborating with Amazon, Intel introduced the Intel Speech Enabling Developer Kit, consisting of Intel's Dual DSP (with inference engine), an 8-microphone circular array and a high-performance algorithm suite that supports noise reduction, acoustic echo cancellation and a customized wake word engine optimized for Alexa.

While Google continues to make strides in the marketplace with its Google Assistant-based devices, and Apple has recently jumped into the smart speaker market with its HomePod (with mostly negative reviews of its Siri implementation), Amazon continues to be the clear leader in this space by licensing Alexa to a wide array of non-Amazon speaker and smart devices.

Intel obviously sees synergy between its smart home goals and Amazon's. Alexa has been the de facto standard for home automation via its third-party enablement of skills --- in fact, Amazon closed 2017 with a 266 percent increase in Alexa skills growth over 2016 in the United States alone.[8]

All of this is built around Intel's desire to become the AI platform of choice by creating a distributed, local compute architecture that makes it easy and resource-friendly for partners to develop new solutions.

A "BEST IN CLASS" CONSUMER EXPERIENCE

One of the repeated themes that one discerns from speaking with Intel's smart and connected home executive team is that the company is genuinely concerned about the overall consumer experience in the connected home. Many consumers, even knowledgeable ones, tend to define the smart home solely using a digital assistant.

This superficial definition tends to miss the important point that solutions like Amazon's Alexa, Google Assistant, Apple Siri and even Microsoft Cortana are merely interface replacements for the keyboard, mouse and touchscreen. It is because these are the obvious and repetitive layer between the user and a smart home action/activity that they

[8] https://www.voicebot.ai/2018/01/08/amazon-closes-year-with-266-alexa-skill-growth-u-s/

have tremendous visibility with the consumer. To paraphrase the late Rodney Dangerfield, for many consumers, everything in the home BUT the voice interface seems to get "no respect."

Intel activities appear firmly focused on creating a "better together" experience for consumers in the smart home. In this regard, one could consider Intel's smart home strategy to be analogous to the human body; with connectivity being a proxy for the circulatory system; audio, optical and speech capability substituting for ears, eyes and voice; and finally, neural network engine, AI and machine learning replacing the brain's cognitive function. Intel's acquisition of car-vision company Mobileye in March 2017 for $15.3B, as well as its September 2016 acquisition of Movidius, specializing in low-power processor ASICs for computer vision and deep learning, are non-trivial examples of how Intel is leveraging other portfolio technologies within the company to invest in the future of the smart home.

Intel is putting into place these fundamentals that are designed to create a great proactive customer experience with products that require these types of capabilities. With these pieces in place, it is not difficult to envision a world where tomorrow's smart home not only listens for your voice commands, but also looks and listens for anomalies that it can act upon in advance (a basic example: your home recognizes who you are when you arrive home and instantly turns on the lights).

HOW DOES INTEL DISTINGUISH AND DIFFERENTIATE ITSELF?

Intel enjoys several advantages as it begins to execute its connected home strategy. Several of these advantages are not totally new and have been Intel differentiators for years, but the multiplier effect of these advantages creates additional momentum for Intel, especially at the partnership and third-party vendor level where the battle for the smart home will essentially be fought.

Intel is armed with an impressively broad portfolio of products — SoCs, WiFi chipsets, the Ethernet physical layer (PHY) and voice chipsets for cable, fiber, DSL, retail and 5G gateways — and Intel offers this for all broadband access technologies, which is unique in the industry. Few vendors offer this type of "one stop shopping" of the key technology ingredients that show up in the most popular home connectivity devices. Intel also is pushing Intel Architecture (IA) processors with developers to incorporate them into personal assistants and smart speakers. IA processors have all the ease of design engineering, integration and qualification benefits that Intel OEMs have enjoyed for years.

IA processors also are sold into consumer and SMB network attached storage devices for securely storing data locally, an increasingly important requirement in the connected home.

Intel solutions span the product spectrum from cloud to client, and that translates into a comprehensive and complete offering to service providers. These assets become particularly important in the connected home, whether it be based on 5G, AI or chipsets.

With few exceptions, Intel always takes an active role in standards. This is perhaps even more important in the connected home area; developers tend to have finite resources and simply do not have the ability to embrace multiple standards. Intel's strong support and participation with associations such as Cable Labs, the Wi-Fi Alliance and IEEE should continue to assuage the concerns of any developer that it might "go it alone" in its desire to drive further penetration into the smart home.

Finally, there is the legacy Intel brand. Despite recent security issues with its processors that arose in late 2017, it's hard to think of another company on the planet that enjoys the same type of strong OEM and developer relationships that Intel has garnered. Though these relationships should never be taken for granted, Intel is in a powerful place to leverage them for its plans in the connected home.

CONCLUSIONS

It is clear the smart home represents a great business opportunity and challenge for the 49-year-old company. More than a few industry prognosticators have predicted that several of Intel's core businesses will see flat or modest growth over the coming years, and the company appears to recognize that success in the smart home is not an optional goal. There is a "virtuous cycle of growth" characteristic to what Intel is attempting to do in the smart home, since enabling better connectivity, as a result of consumers connecting more devices to the cloud, creates an unquenchable thirst for more data.

From an ingredients standpoint, Intel is positioned to satisfy the growing demand for IoT devices that is clearly occurring in the marketplace. Intel is focusing on the infrastructure/connectivity elements of the smart home, as well as the AI-class digital assistant solutions that are poised for huge growth over the coming years. Importantly, they have chosen to not take an Intel-branded approach for end user solutions that could confuse partners and consumers.

In a sense, they have opted to remain on the proverbial sidelines by staying fixated on infrastructure (the smart home "super highway" if you will) and let partners do what they do best --- innovate at the end user level. Refreshingly, there is no executive chatter about a very public *Intel Inside Connected Home* program for the smart home. There is remarkable humility in Intel's connected home approach and that's not a bad thing.

What struck this analyst as equally remarkable during my extensive interviews was the commentary consistency between all senior smart and connected home executives at Intel. Rarely does an analyst see this type of behavior when speaking to multiple company executives; potentially a sign that their smart home strategy is firmly ensconced at a leadership and company level.

Intel's success in the smart home may be determined by factors that the company simply cannot control. Numerous articles have been written about the sheer complexity of the smart home[9] (for example, Amazon claims that more than 4,000 devices from 1,200 brands now support Alexa[10]), and that complexity could catch up with frustrated consumers and slow down sales expansion.

Secondly, cable providers may not move rapidly enough to upgrade their broadband infrastructure to provide cost-effective symmetrical services to allow them to compete against fiber-based deployments. The Full-Duplex DOCSIS standard is an attempt to leverage the existing coax infrastructure to deliver both faster and symmetrical speeds without having to invest in a complete overhaul of the existing cable plant. Also, consider that the cost of providing fiber-level access to consumers' homes is still between $1,000 to $2,000 per home, prohibiting wide-spread adoption of fiber in legacy cable networks.

There is also the wild card of the vaunted 5G rollout. While Intel views all pipes to the home in a neutral manner, 5G could accelerate smart home adoption in remote markets that don't have access to high speed cable or fiber. 5G is not a substitute for symmetrical fiber, but it will be a boon for those consumers in remote markets that have never had access to even DSL-class speeds. With that in mind, 5G may be a tailwind for Intel's connected home plans, but it will largely depend on how quickly wireless companies roll

[9] https://www.nytimes.com/2018/02/21/technology/personaltech/smart-things-dumb-stuff.html?smprod=nytcore-ipad&smid=nytcore-ipad-share

[10] https://www.usatoday.com/story/tech/columnist/baig/2018/01/12/smart-home-sounds-like-great-idea-so-

out 5G, and some media reports indicate that the initial deployment will be modest over the next 12 to 24 months.[11]

There are signs that Intel's connected home approach is getting traction. Intel's partnership with Amazon has generated the popular Echo Show and Echo Look digital assistant products. In the China market, JD.com recently partnered with Intel and announced the DingDong Play, an Intel Atom-powered smart personal assistant featuring a smartscreen and voice capability. On the router front, Intel's efforts with ASUS produced their stylish Blue Cave Wi-Fi Router that features Intel's aforementioned WiFi chipset. And the company is developing new 802.11ax chipsets that undoubtedly will lead to the announcement of new high-performance routers that are optimized for faster, low-latency content streaming, video calls and more.

Barring some type of high-profile, massive security breach at the smart home device level, and/or a similar privacy fissure occurs with a smart digital assistant-class product, marketplace momentum in the smart home is likely to continue at breakneck pace. Intel's strategy, while decidedly pragmatic, will require patience and long-term commitment, especially at the senior executive level, for success tends to take time as fractured markets sometimes produce unexpected winners.

Pragmatism does not mean that Intel should be shy or reserved about strongly promoting and communicating its infrastructure intentions in the smart home. For Intel, one sign of success will be if its vast partner network can consistently articulate the elements and benefits of its connected home infrastructure plan to consumers and the media alike. An *Intel Inside Part 2*-style program is certainly not called for, but Intel should continue to strongly partner with those companies willing to carry the water and espouse the rationale of what Intel is trying to achieve in the smart home. OEMs will welcome Intel's support in this area as they have complementary objectives, and the right social media campaign activity can help do this in an appropriately targeted and cost-effective manner.

The big cable providers, especially COMCAST, represent an excellent opportunity to help promote Intel's smart and connected home strategy in context with its infrastructure improvements. While the cable providers do transition their infrastructure at a slower pace than Intel would prefer, the upside is that Intel has more timeline runway than normal to educate consumers. One opportunity might be to partner with COMCAST in their

[11] https://www.wsj.com/articles/wireless-companies-to-start-small-with-5g-rollouts-1519480800

nearly 500 Xfinity stores across the United States for long-lead communications of their joint technology engagements.

Going forward, Intel would be well-served by continuing to pursue and promote high-profile partnerships, such as the one with Amazon, that would underscore to the market that the company is serious about capturing as many design wins as possible in the digital assistant category. While Amazon is not the only player in the digital assistant category, it is the clear leader, and as its presence at CES in January confirmed, it is racking up a number of impressive wins with third-party, non-speaker devices that have embedded Alexa functionality. Intel's partnership with Amazon in this area is a powerful affirmation of its connected home strategy and allows it to participate in the powerful ambient computing tsunami that the market is currently experiencing. Noticeably absent in Intel's digital assistant plans is significant engagement with Google, and it would behoove Intel to rectify that gap as Google is a serious challenger to Amazon.

Given its long history with PC OEMs, Intel will likely see strong traction in notebooks with its Smart Sound Technology solutions, which can enable popular Amazon Alexa-class capability. Consumers are not accustomed to this capability being available in PC-class products and Intel will have to work closely with OEMs on creative ways to promote this feature in retail stores, which could be challenging given the ambient noise challenges in stores.

While unpredictable things can always happen, the company's overall strategy fundamentals in the smart home space appear to be sound, realistic and timely given the configuration of today's smart home market, and this analyst believes they are on the right track.

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