

Voice Wars: Smart Speakers, Voice Assistants, and Strategies for Building a Successful Voice Ecosystem

by

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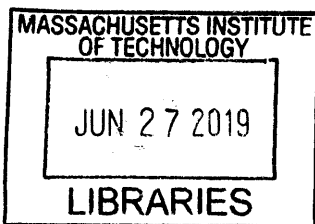
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ABSTRACT

In recent years, voice-powered digital assistants have exploded into the consumer mainstream as an important new form of human-computer interaction. Powered by dramatic improvements in speech recognition and artificial intelligence (AI) technologies over the last decade, digital voice assistants are now abundantly prevalent in modern consumer electronic devices ranging from mobile phones, to smart speakers, to wearables. As the technology matures and the availability of big data used by digital assistants proliferates, voice will soon become a primary modality by which people interact and accomplish tasks. Many of these tasks will be accomplished in consumer homes and digital voice assistants present a significant new opportunity where voice and the physical home intersect to dramatically reshape how consumers live in their home.

This also represents a tremendous opportunity for companies in the digital assistant industry, and, in order to successfully leverage this nascent technology, they will need to understand both their own strategic goals as well as their direct and indirect competitors' strategies in building a business ecosystem around voice-first digital assistants. A fierce struggle has begun - not just amongst current technology titans (i.e. Google, Amazon, Apple, Microsoft), but also involving key incumbent players in the home media and electronics industry (e.g. Samsung, Sonos, Bang & Olufsen).

The goals of this thesis, with respect to the current industry leaders in the digital assistant and smart home space, are to 1) understand the current landscape of the digital assistant voice ecosystem, 2) elucidate each major players' current voice-powered digital assistant platform strategy, 3) analyze the consumer adoption, selection, and diffusion mechanisms for digital voice assistants in the consumer smart home, and 4) determine what the likely outcomes are for each major player as well as the likelihood of success and associated risks with the current ecosystem and platforming strategies employed.

Finally, through additional market analysis and industry projections, strategic recommendations will be presented to guide each key player over the next decade. Following these recommendations will be key to winning the digital assistant voice wars and for creating a successful and sustainable voice technology ecosystem in the personal digital assistant market.

Thesis Supervisors:

Michael A.M. Davies - Senior Lecturer, Integrated Design & Management Program

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Definitions

First-party Services – services or applications native to the digital assistant that are developed and distributed by the original device manufacturer (e.g. playing a song, drafting an email, getting information about your online order, setting a reminder, turning off the lights, getting directions, etc.)

Third-party Services – applications that are developed by an entity that is not the original vendor of the development platform

Utility - the degree to which the assistant can usefully accomplish a wide set of tasks across many domains in the home

Reliability - the degree to which the assistant can perform consistently well for a particular set of tasks (both in the context of ASR and intent)

Trust – a measure of the user’s confidence on the reliability of their digital assistant

Platform War – a platform war occurs when platform providers engage in a competition to build a technology platform to attract users on multiple sides of the market. With multi-sided markets, platform companies compete on not just product and price, but also on the strength of both direct and indirect network externalities on each side to bring together even more buyers and sellers

Open/Closed Platform – attributes of platforming strategies wherein the degree of openness depends on the level of control exerted by the platform provider. Platform providers can employ a closed, open, or a varying mixture of open and closed strategies to exert what level of control it would like over the players utilizing its platform

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Introduction

The Digital Assistant Voice Wars

A new war has broken out and the latest battle was on full display at CES 2019, an annual trade show held on January 8, 2019 in Las Vegas. Those with the deepest pockets in tech, (Google, Apple, Amazon) went all out at the popular electronics convention, including taking out full-building advertisements, employing an army of uniformed company ambassadors touting the latest integrations with their companies' voice assistant, and generally, infiltrating nearly every corner of the tradeshow and beyond in Las Vegas. Everyone wants to be your favorite voice assistant.

Voice-powered digital assistants were first introduced into the consumer mainstream beginning with Apple's digital assistant, Siri, in 2011 but in recent years new offerings from Amazon, its Alexa, and Google, its Google Assistant, have exploded onto the scene in the form of smart speakers, voice assistant applications residing on smart phones, and connected digital consumer devices. Indeed, as we see at CES device makers have rushed to incorporate both Google Assistant and Amazon Alexa in their smart devices, ranging from smart microwaves, to smart garage doors, to of course the smart speaker. Apple while not present at CES, already has deep penetration with Siri, given that over a 1.4 billion active Apple devices are out in the world. (Lee, 2019). It's clear that it has redoubled its efforts to improve and develop Siri notwithstanding the perception that they have fallen behind. Though it was the first to market with Siri on the iPhone 4S, the recent forays into this space from Amazon and Google have clearly motivated Apple to improve Siri. Apple is not about to give up in the digital assistant space.

Amazon, while being relatively late to the game, released the Amazon Echo line of smart speakers in November of 2014. It surprised everyone when it unveiled Alexa in the smart speaker form factor and it has been relentless in introducing new devices enabled with its digital assistant. Interestingly, Amazon has not only released its own line of hardware devices with Alexa, including well over 70 Amazon made devices now, but it has also integrated with many incumbent electronics vendors. Quite impressively, Alexa now supports over 20,000 devices

worldwide (Heater, 2018) and over 100 million devices with Alexa have been sold (Bohn, 2019). Amazon is going all in in this war and it seems it is not relenting.

Google, while being the latest major player to enter with their Google Assistant product in May of 2016 had the biggest presence at CES 2019. Later that year after the unveiling of Google Assistant, the first Google Home smart speaker enabled with Google Assistant was released and similarly to Amazon, Google has been developing and building more hardware that supports Google Assistant. Google also has an advantage in that its Android operating system devices are already enabled with Google Assistant. With deep penetration of Android worldwide, Google expects its assistant to be available on over one billion devices by the end of January 2019 (Huffman, 2019).

While these three are the current major players, a number of other key players are also present in the digital assistant war. Microsoft has its Cortana digital assistant although recent development has waned and indeed, it seems Microsoft is perhaps shifting its Cortana strategy to target enterprise and potentially create alliances with the likes of Alexa. Samsung, with its deep expertise across many consumer electronics sectors, not just its line of Galaxy smartphones, but also appliances and additional electronics in the home, has Bixby which boasts an impressive number of installs. Finally, we have a number of hardware device makers who look to either integrate one of the existing voice assistants or multiple of them. For example, Sonos has smart speakers that are powered by Alexa as well as Google Assistant.

The battle to be the dominant digital assistant for the home is heating up, and no clear winner can be declared yet. This represents another fundamental platform war potentially being played out with massive implications for the current technology titans.

Motivation

In almost any dense urban city in the world, walking down the street is an eerily similar experience in some ways – people glued to their personal smartphone devices, many barely registering what is in front of them and most rarely interacting with the anyone else around them. With the expected number of global mobile phone users to exceed five billion in 2019

(eMarketer, 2016), it's clear that the smartphone is now an indispensable part of everyone's lives.

On the one hand, the smartphone has made our lives immeasurably better. We are able to communicate and connect with people around the world with unprecedented ease at breakneck speeds. With this convenience, however, lies the dark side of technology. I happen to remember a time in my youth when I did not have a pocket-sized super-computer at my disposal at all times of the day. In high school, my friends and I actually called each other on landlines and wrote notes on paper to each other. We had endless amounts of inane high-schooler debates without the help of instantaneous answers thanks to Google. We never spent hours curating the perfect selfie to post on social media for all our virtual friends to see (and then obsessively check how many and who liked the post). In short, technology did not dominate our lives as much as it does to kids and adults alike today. The topic of voice as a human-computer interface caught my attention as soon as I received my first iPad enabled with Siri in 2013. While Siri didn't work great when it first came out (and it can be argued that in some instances it still does not work that well today), it opened a realm of possibilities of a more natural means of interacting with our computing devices. Communicating with a tiny five-inch piece of glass may be normalized in today's society, but I believe that it is not how humans were intended to communicate with each other. People should be able to accomplish tasks and communicate through multiple mediums beyond a brightly lit text-laden screen. We communicate our ideas and get things done through gestures, voice, touch, and sometimes even smell. The personal computing technology we use should be a tool to help humans be more productive and make meaningful, social connections; instead, some have argued that technology like today's smartphone has become an addiction that has had real and measurable adverse (Severin Haug, 2015) effects on the human population. I see audio and voice, one of the most basic and natural human communications modalities, as a first step to realizing a more natural way for humans to interact with technology and each other.

While I have always been deeply interested in technology and the human condition, my personal interest in voice technology, especially in the digital assistant space, culminated in the summer of 2018 when I took part in an internship at Apple. I had the privilege of interning as a product manager working on Siri. More precisely, I worked on building the knowledge graph that powers

Siri which meant helping Siri know more about the world around her. At Apple, I saw firsthand how passionate each person was in building transformative technologies that preserved the human in human-computer interaction. Although I was only there for one summer, I believe that I made a real measurable impact on the quest for humans to building a truly intelligent, conversational digital assistant. While there is still a long way to go to achieve that dream, I know that I both want to be and know that I will be a part of bringing about that change. I believe that voice-powered digital assistants are a critical step to eventually allow us to build personal computing technology that augments human capabilities and actually allows us to be more human and less reliant on technology.

I believe that this is truly a transformative time in human-computer technologies and we are on the threshold of a revolution powered by AI and big data that is as profound as the internet revolution in the late 1990s. The hope is that this thesis is a step towards understanding how can companies leverage this nascent technology, and what will it take for them to build a sustainable ecosystem on the road towards a truly intelligent voice-powered digital assistant that can make all our lives richer and more meaningful.

Hypothesis

This thesis will attempt to answer two sets of fundamentally important questions in the digital assistant voice wars. The first set of hypotheses (**H1x**) will revolve around the questions of why some consumers are currently not using digital assistants and how companies can drive increased digital assistant usage. The second set of hypotheses (**H2x**) will address how companies can craft a digital assistant strategy to win in the long-term.

The hypotheses for the first set of questions are as follows:

H1A: Digital voice assistant usage (both volume and variety of tasks performed) remains low relative to touch-based device usage because users have become habituated to accomplishing tasks through gesture, text, and visual modalities on screen-based devices.

H1B: Furthermore, even though users may readily have access to a digital voice assistant, especially with the rise of smart wearables, many are not aware of the capabilities of their digital assistant. This is partly due to perception that digital assistants are “dumb” or “useless” (whether from past personal experience or popular media), and partly due to the ever-changing capabilities of assistants (i.e. what was not possible even a few months ago may be possible now).

Large-scale consumer behavior change is difficult so we need to start small to more easily induce behavior change - by building awareness and encouraging users to switch from accomplishing simple (i.e. first-party services) tasks via smartphone touch interactions to using their digital voice assistant. The key is to ensure that task inputs and outputs remain consistent with a user’s mental model for accomplishing the same task through traditional touch modalities (e.g. If a user asks Siri, “What time is my dermatologist appointment?”, then she should expect to receive the same answer as when she opens up the iCal app and types to search for her appointment).

H1C: More generally, for companies to increase digital assistant usage, they must start by ensuring a reliable and seamless experience on first-party services - that is, utilities provided natively by the voice assistant. Examples of first-party services include playing a song, drafting an email, getting information about your online order, setting a reminder, turning off the lights, getting directions, etc. Currently, most consumers accomplish these tasks through first-party apps without the help of a digital voice assistant. Since smartphone companies oftentimes directly control the user experience on these first-party services, if they can ensure a great digital assistant experience in accomplishing first-party tasks, this will build user confidence in their digital assistant and encourage users to increase their digital assistant usage.

H1D: Finally, as the capabilities of these assistants are carefully expanded (i.e. as assistant utility improves), consumers will realize higher perceived value and entrust their digital assistants to perform increasingly complex and varied tasks. Users will then gradually become habituated to using their digital assistant for a greater volume and wider variety of tasks.

Further increased digital assistant usage across different domains will then allow companies to build not only a more *context-aware* digital assistant but also a more *personalized* digital assistant tailored to the needs and wants of each specific user.

The second set of hypotheses revolve around crafting a sustainable digital voice assistant strategy and are as follows:

H2A: For companies to win, it is not enough to simply have a large install base of digital assistants.

H2B: Rather, increased digital assistant usage across many contexts, both in terms of volume of usage and variety of tasks performed, is what allows companies to gather more data to better inform their machine learning systems. Specifically, increased volume of usage enables more accurate predictions across user queries and increased variation of assistant tasks enables improved expansion and performance of complex and varied consumer use cases.

H2C: This results in a better digital assistant product which drives further assistant usage.

H2D: Ultimately, this results in a powerful positive reinforcing feedback loop.

To sum up, as digital voice assistants mature and are shaped by their companies' strategic goals, each with their own criteria for success, the one or few assistants that will capture the market and have sustained success in the consumer smart home will be the assistant that performs most reliably and seamlessly on first-party services. This will result in sustained, habit-forming digital assistant usage which allows companies to build stateful, hyper-personalized digital assistants that consumers will trust with every aspect of their life. Ultimately, users' reliance and trust of their specific digital assistant will create significant switching barriers for other competitors and be the key determinant for long term success.

Background and Literature Review

Digital Assistant History

Digital Assistants have a long and storied history dating back over nearly 60 years of commercial and research usage. One of the first digital assistants presented to the general public was at the 1962 Seattle World's Fair where the IBM Shoebox (IBM) was introduced. This primitive digital assistant was able to recognize and transcode user speech on a limited set of inputs, perform basic arithmetic, and display the results to the user. Research in speech recognition and digital assistants continued to progress and by the 1970s, the Defense Advanced Research Agency (DARPA) in conjunction with Carnegie Mellon University introduced Harpy (Moskvitch, 2017), an assistant that amassed a 1000-word vocabulary which was equivalent to that of a three-year-old child.

In the 1990s and 2000s, the rise of personal computing and smartphones brought about much improved speech recognition in both hardware and software systems, culminating with the introduction of the first modern digital assistant, Siri. Apple introduced Siri on its flagship iPhone 4S in October of 2011. As automatic speech recognition has dramatically improved in recent years, the technology may finally be ready for the mainstream. As anyone who has recently attended CES or has been following what the biggest names in tech are working on, there has been an explosion of voice-activated digital assistants from technology titans, such as Google Assistant (Alphabet), Alexa (Amazon), Cortana (Microsoft), Bixby (Samsung), and of course, Siri (Apple). As voice recognition capabilities continue to improve, powered by smaller, cheaper, and faster hardware, digital assistants are finally entering an age where I believe that mainstream mass adoption is about to take off. I believe that voice assistants will soon become a primary way in which people interact with and accomplish tasks in their home.

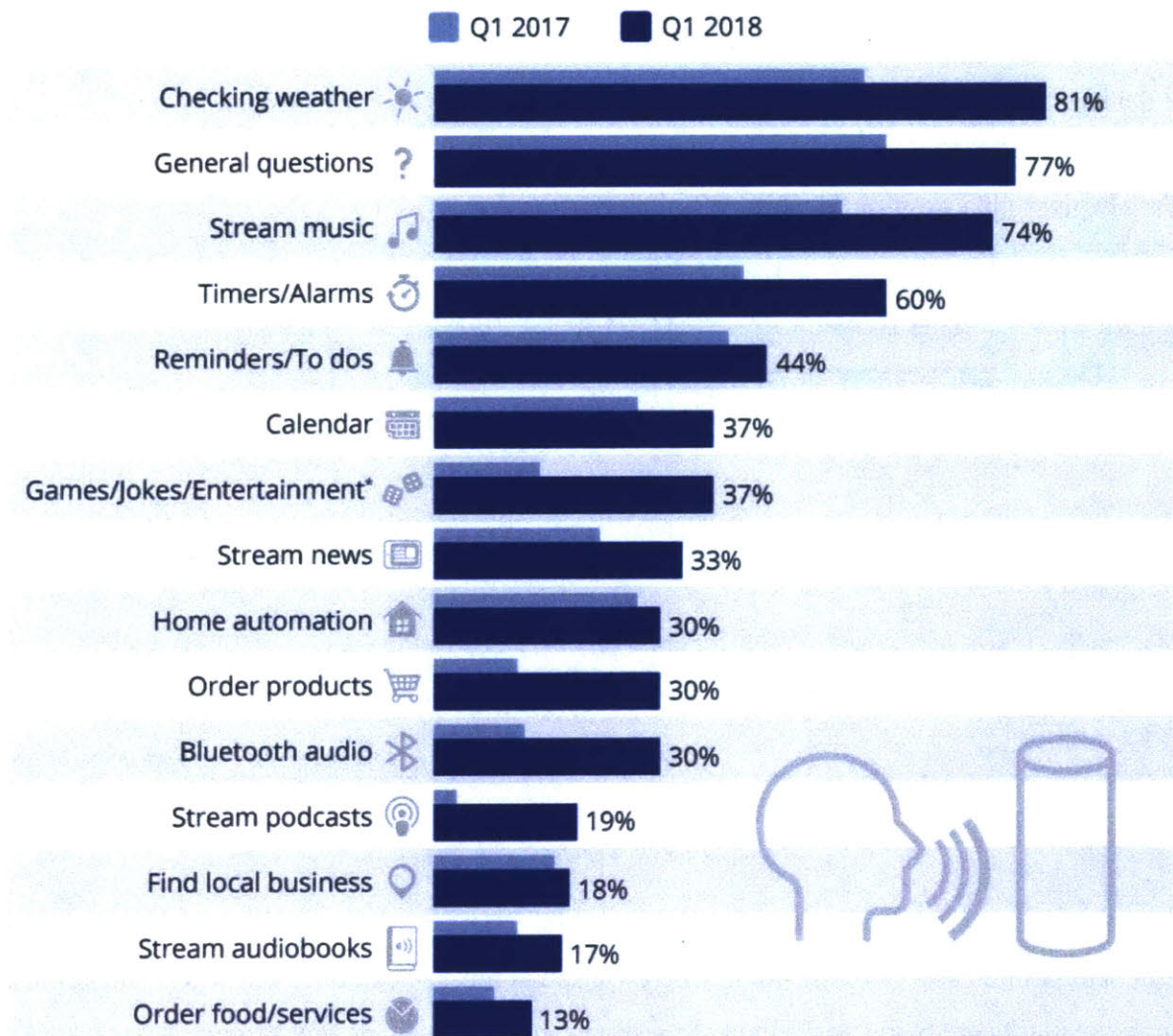
Voice in the Smart Home

As users gain exposure to digital assistants either through their smartphone device or with a digital assistant-enabled device in their home such as a smart speaker, it is imperative to understand what kinds of tasks might be performed and where digital assistants are currently being employed today. Assistants such as Alexa, Google Assistant, and Siri are increasingly

being used for a broad range of tasks from simple tasks such as playing music or texting a friend, to medium complexity tasks such as looking up a recipe, turning off the bedroom lights, to more complex tasks such as making a haircut appointment at a barbershop. The following figure displays a breakdown of the most commonly performed tasks with a smart speaker digital assistant as well as percent of owners who have used the smart speaker to perform the associated task.

Users Learn to Appreciate Smart Speakers' Many Talents

% of smart speaker owners in the U.S. who have used the device to do the following



* category was limited to "playing games" in Q1 2017 survey
 Base: U.S. households owning at least one smart speaker
 Source: comScore

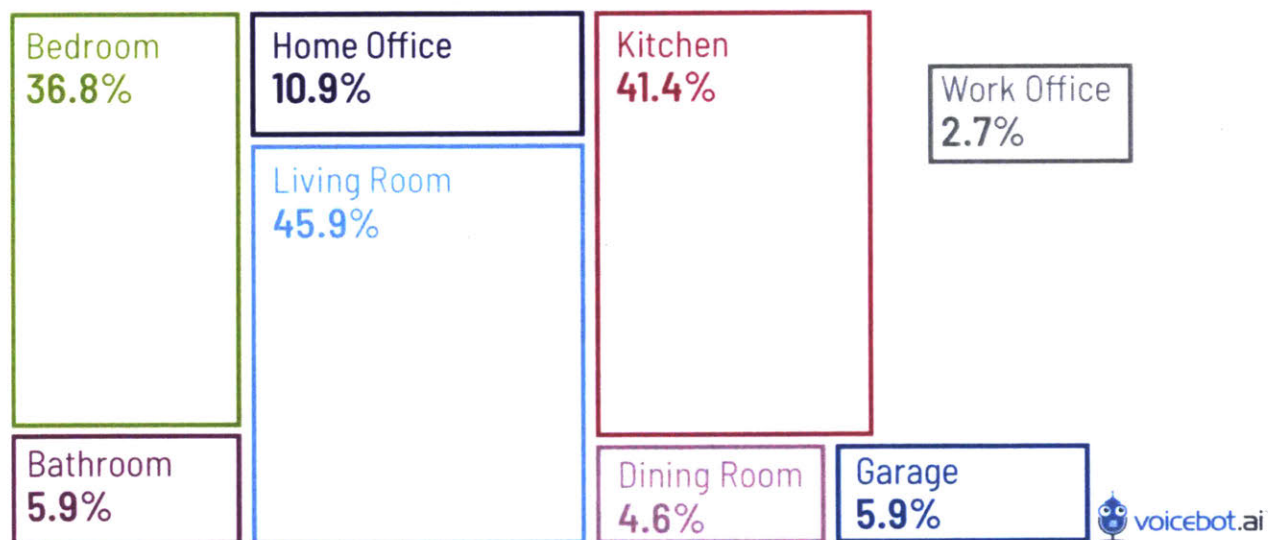


Figure 1 Smart Speaker Use Cases

It is notable that use cases involving more complex tasks such as ordering food or services remains relatively low and users are still mostly only accomplishing basic tasks such as listening to music, setting timers, or checking the weather.

The second dimension in understanding voice in the smart home is to understand where these tasks are being asked and performed by digital assistants. This will help elucidate what are the most important use cases for consumers currently. The graphic below shows that the most common location for digital assistant use with a smart speaker are in the living room, kitchen, and followed by the bedroom. In conjunction with the current popular tasks and these locations within the home and mobile device arena, it makes sense to see the most common locations for these devices in areas of the home where routine tasks need to be accomplished.

Primary Household Location for Smart Speakers



Source: Voicebot Smart Speaker Consumer Adoption Report January 2018

Figure 2 Primary Location for Smart Speakers

More concretely, we see that most of the placement for smart speakers resides in the living room and kitchen – public spaces in the home where we spend most of our time and where most of the home-related tasks are being performed. This shows that a significant opportunity exists where a digital assistant can provide real value for users in the living room and the kitchen where common tasks such as turning appliances on, or controlling home media electronics are most likely to occur.

Industry Dynamics

Market Drivers

Although digital assistants and its related technologies have been around for well over 50 years, it begs the question why have they only seem to become so popular in recent times? The answer lies in the fact that most of the work has been confined to research labs in university and governmental agencies as referenced in the previous section. Most recently, the rise can be attributed to three primary market drivers: 1) the improvement in electronics hardware technologies and the associated commoditization of hardware components leading to reductions in price, 2) improvements in automatic speech recognition and natural language processing technologies, and 3) availability of vast quantities of digital data for use in AI and machine learning (ML) systems. Technology behemoths such as Apple, Alphabet, Amazon, and even Facebook have collectively poured billions of dollars of research into digital voice assistants over the last decade and their investments in this space along with these market drivers are creating an unprecedented opportunity for digital assistant growth in recent years.

The first major enabler for digital assistants has been the improvement in digital electronics hardware, particularly for the smartphone. Thanks to Moore's Law, smartphone hardware has drastically improved even as component prices have fallen. Today's smartphones have more computing power than the computers that were used to put NASA astronauts on the moon (NASA, n.d.). Indeed, the figure below shows the tremendous improvement in recent year for smartphone performance. We see that after the introduction of the iPhone in 2007, the processing speed improvements began slowly at first but dramatically improved in the mid-2010's and has continued to improve. Smartphones nowadays are essentially pocket-sized supercomputers and with each release become even more powerful.

GeekBench (multi-core) by Brand

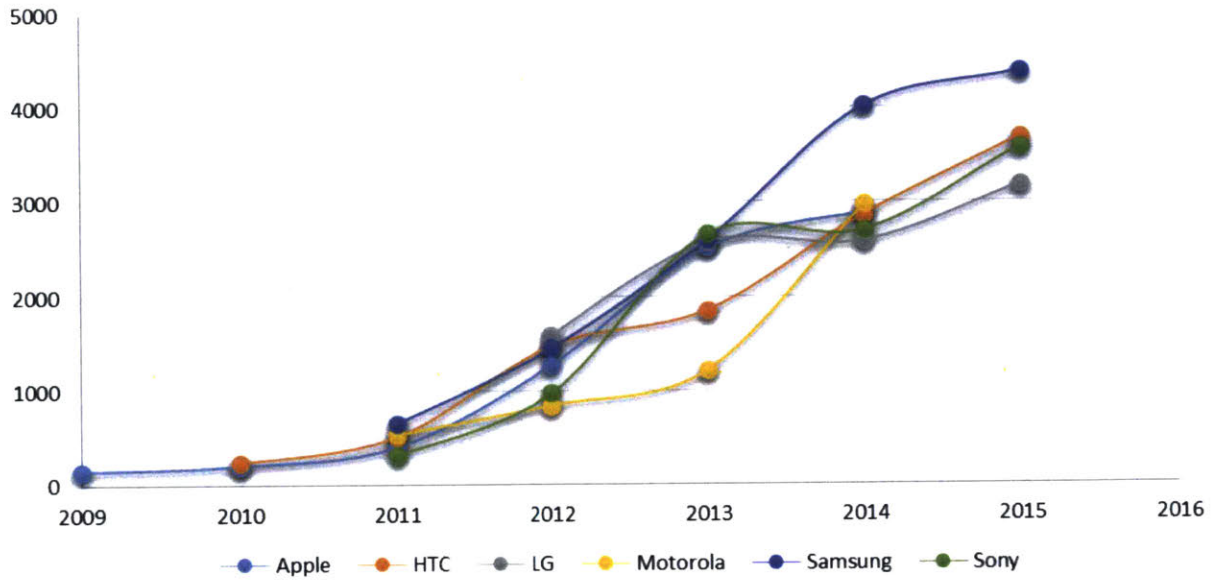


Figure 3 Smartphone Processing by Brand

Smartphones that have greater processing power enable better speech recognition systems and improved on-device computation necessary for digital assistants.

While smartphone hardware technology continues to drastically improve, their cost to consumers has stayed relatively the same and are predicted to remain so. As seen in this figure, the average price of smartphones in the United States has remained essentially the same since 2012 and is predicted to remain static in the coming years.

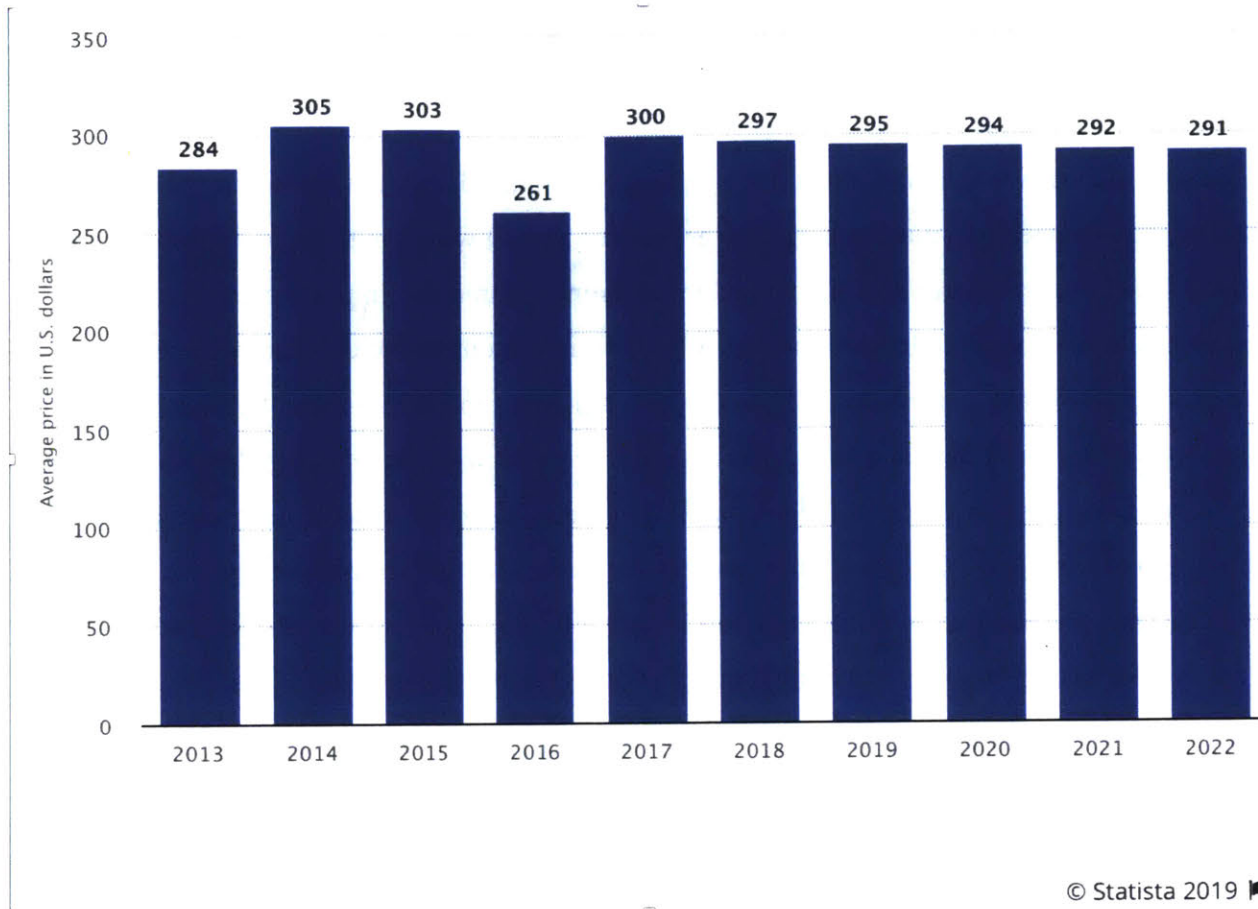


Figure 4 Average Smartphone Prices in US

This is a huge enabler for digital assistants as smartphone hardware improves at essentially the same cost bringing better technology to consumers.

The specific components that are being used in smartphones are now also being used in smart speaker devices. Digital assistant enabled smart speaker devices have now been priced as low as \$30 as Amazon and Google have engaged in price wars. With how quickly the prices for these devices have fallen, smart speaker penetration has now reached critical mass in the United States with 41% penetration and is predicted to continue to grow in the coming years (Perez, 2018).

The ubiquity of smartphones and increasingly smart speakers in the home reveals a tremendous market shift driven by improvements in hardware, along with dropping prices of commodity components that are used in these devices. As smart enabled devices continue to diffuse and

penetrate into the consumer home, more and more consumers will have access to a digital assistant via multiple mediums.

The next market driver that has enabled the diffusion of smart devices in the home are the dramatic improvements in natural language processing (NLP) which in large part have been fueled by the broader improvements in machine learning techniques. In particular, companies now have access to unprecedented amounts of data from customers. With billions of devices out there around the world, companies such as Google, Amazon, and Apple are collecting tremendous amounts of data and using that data to train their machine learning algorithms. A big beneficiary from this explosion in the availability of data and improvements in machine learning techniques is the ability for voice digital assistants to recognize spoken human speech.

Automatic speech recognition (ASR) is a subfield of NLP and is one of the first key steps for a digital voice assistant to process a human query. The figure below depicts NLP and ASR in the process of understanding a query.

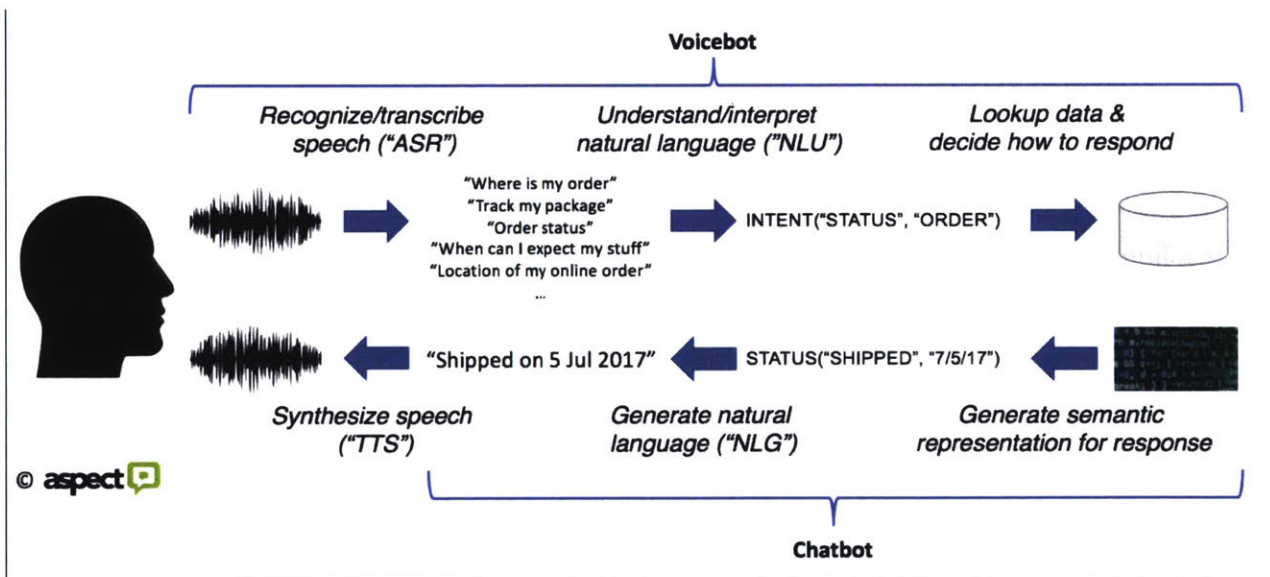


Figure 5 Natural Language Processing Flow

Although automatic speech recognition (ASR) has been around for many years, including a substantial push from the United States military technology research branch, DARPA, in the 1970's, only recently has it been able to achieve word error rates on par with human transcribers. Less than two years ago, researchers at Microsoft reached an important milestone when they

developed a speech recognition system that recognizes words used in conversational human speech as well as a human transcriber does. Word error rate, a key performance metric used in ASR, essentially measures how many substitutions, deletions, and insertions occur from what the ASR system hypothesizes versus a reference string. In February of 2017, researchers at Microsoft were able to achieve word error rates of 5.9 percent (W. Xiong, 2017), reaching parity with humans. They used a specific technique in machine learning known as convolutional and long short-term memory (LSTM) recurrent neural networks to achieve this feat. While this was achieved in a laboratory setting, researchers and companies alike have been quick to roll this technology out to real life settings. We now have voice assistants that can not only identify which words are being spoken, but differentiate between who is speaking them (Pinsky, 2017). Shortly thereafter, voice assistant technology can now even recognize human speech quite well in noisy environments (Wilson, 2018) such as parties. These improvements become huge enablers in ensuring digital assistants can be just as good as humans in recognizing when they are being queried and what they are being asked to do.

This has huge implications for voice-powered digital assistants because as these ASR systems continue to improve, we are now able to rely on them to recognize what we say far better. The caveat is that we need to be careful and make the distinction between these systems being able to recognize what we say, and truly understanding what we mean. As mentioned before, speech recognition is but one step in natural language processing – the remaining steps, including named entity recognition (i.e. can the assistant recognize proper nouns?), and language understanding (i.e. does the assistant understand the user’s intent?) become much harder problems, but aided by vast amounts of training data and breakthroughs in machine learning techniques, assistants are improving every day. As companies gather more and more training data to improve their digital assistants along with the tremendous resources already dedicated to NLP research, we should see continued improvements in digital assistant capabilities.

Market Inhibitors

In analyzing the current market trends for digital voice assistants, it is also critical to understand what current inhibitors are in place which may retard the adoption of digital voice assistants in

the consumer home. This section will focus on two of the most salient market inhibitors: consumer data privacy and government regulation.

The first such market force that is most present on consumers' minds is data privacy and more broadly, trust. Social media platforms have had a meteoric rise in recent years with unprecedented user growth, especially for the dominant platforms such as Facebook. As of December 31, 2018, Facebook has 2.32 billion monthly active users (Facebook, 2018) which is a staggering number given that the entire world population only currently stands at 7.6 billion. However, with this growth, Facebook has recently felt increased pressure from consumers and government regulators alike for its practices regarding consumer privacy. The Cambridge Analytica scandal that broke out in March of 2018 caused tremendous damage to Facebook. Monetarily, Facebook may be facing billion-dollar fines (Romm, 2019) from the United States government alone – these fines may be even higher in other parts of the world such as the European Union which have a much stronger stance on privacy. Even more damaging than the financial losses is the loss of trust from consumers. According to a Jebbit consumer trust index report, Facebook is ranked 89 out of 100 (Jebbit, 2019) on companies that consumers trust the least with their data. At one point they were ranked dead last, in the weeks following the report of the Cambridge Analytica scandal.

While these trust issues may seem confined to the Facebook application itself, it has resulted in significant inhibitors to adoption for digital voice assistants, with many consumers now citing privacy and trust as a major reason why they may not utilize a digital assistant (Microsoft, 2019). One such example was the launch of Facebook's Portal product, an Alexa smart assistant-powered smart display with always-on speakers and cameras in November of 2018. While it was rumored that Facebook had been working on this hardware product over many years, the timing of its launch could not have been worse. Revealed merely half a year after the scandal that rocked consumer trust in the social media company, unsurprisingly, Facebook Portal was met with harsh reviews citing numerous privacy and data trust issues. Predictably, many consumers felt uncomfortable purchasing a camera and microphone-enabled product from a company that had a reputation for monitoring and selling users' data. While Facebook has not released sales numbers for Facebook Portal, despite being a good hardware product, the negative sentiment

stemming from the numerous negative reviews due to privacy concerns, the future does not seem to bode well for Facebook's Portal product.

We see from this salient example that privacy of consumer data has huge implications on the adoption of these new technologies. Consumer trust and loyalty can take years to build but one scandal can erase all consumer goodwill. Consumer trust in digital voice assistants is already precarious and even a small software bug can erode user trust, as was seen in the case when Alexa started "laughing" without explicitly being prompted due to a software bug. In fact, many users immediately unplugged their Alexa device when this bug first started occurring (Liao, 2018). This consumer ill-will can then easily move downstream and affect other aspects of a firm's businesses. In some cases, the damage may be irreparable as in the case of the recent #DeleteFacebook social media movement spurred by concerned individuals after more Facebook data breaches were revealed in late 2018. Privacy when using digital voice assistants, especially in the consumer home remains the biggest market inhibitor to mass adoption.

A second, but closely related market inhibitor, especially in the wake of the previously mentioned Cambridge Analytica scandal is government regulation. As technology companies such as Google, Facebook, Amazon, and Apple continue to grow in influence, with trillion-dollar valuations and expanding businesses in many domains, there have been more and more calls to regulate large technology companies (Hoffman, 2018). Government regulation has always played a significant role in the adoption of any new technology but because voice assistants rely on personal data to provide a better user experience, the impact of government regulations can have a substantially greater effect on how digital voice assistants perform compared to past technologies that are not so reliant on access to personal user data. Indeed, there have been substantial talks (Meyer, 2018) about the United States implementing measures similar to the European data privacy regulation, General Data Protection Regulation (GDPR). The main tenets of GDPR can be found in the figure below.

Bigger Responsibility, Bigger Repercussions



Figure 6 Key Changes of GDPR (One Login)

If the United States government were to implement a data privacy law similar to GDPR, this may significantly hamper the diffusion of digital voice assistants, primarily due to increased research and development costs as companies now need to go to extra lengths to ensure that they comply with data privacy regulations. In fact, Google was recently issued a fine over its advertising practices in Europe (Fox, 2019). Indeed, some companies have been prescient and have already incorporated development efforts to ensure user privacy (we will see that Apple is the leader in this space later on). The government landscape with regards to big tech regulation is changing by the day but may have tremendous effects on digital voice assistants, and hence on their consumer adoption rates.

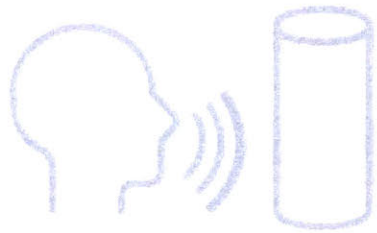
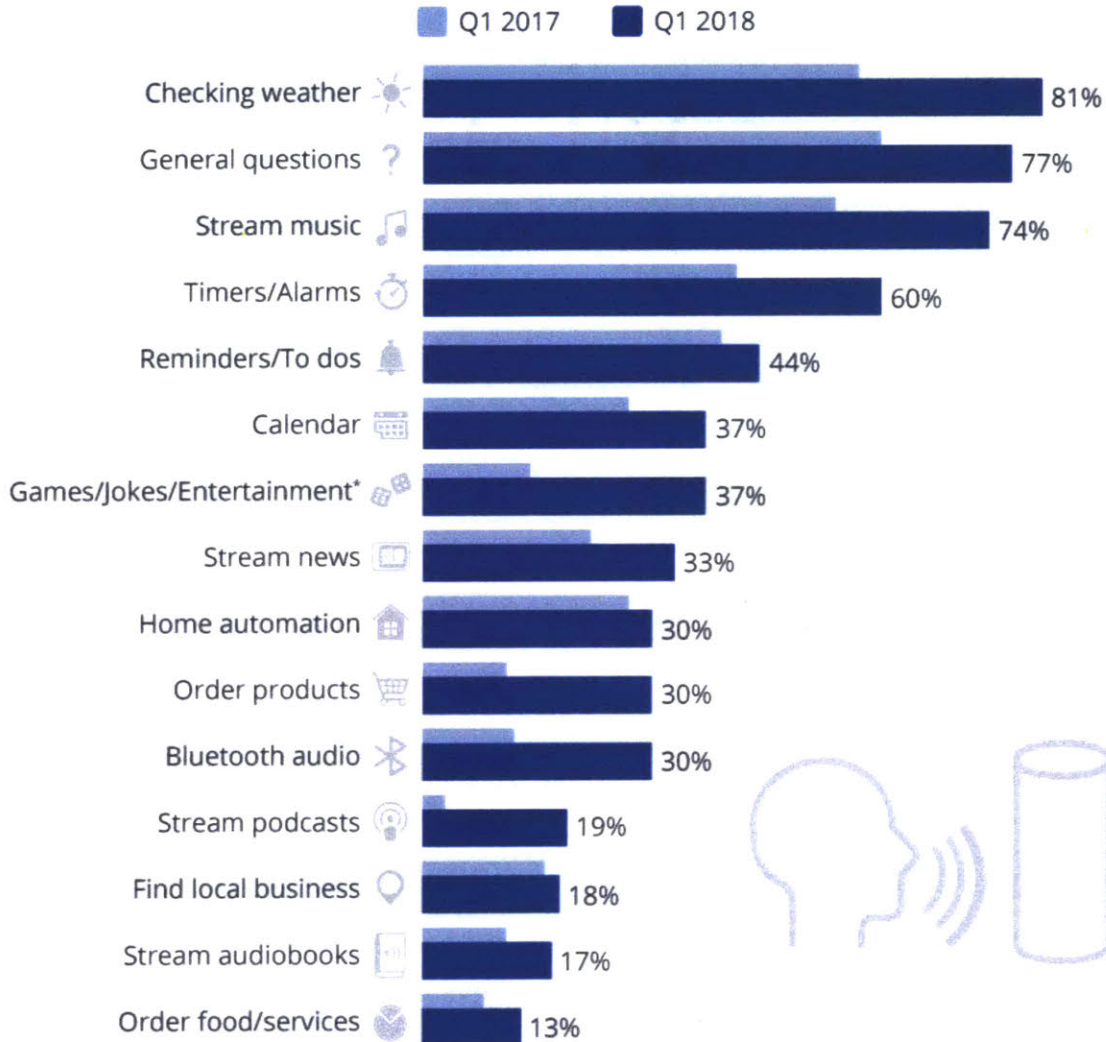
Consumer Needs in the Home

Given our understanding of the broader market for digital voice assistants, it is critical to understand consumer needs in the home with regards to accomplishing tasks through voice digital assistants.

Based on surveys, the following were the most likely use cases by frequency.

Users Learn to Appreciate Smart Speakers' Many Talents

% of smart speaker owners in the U.S. who have used the device to do the following



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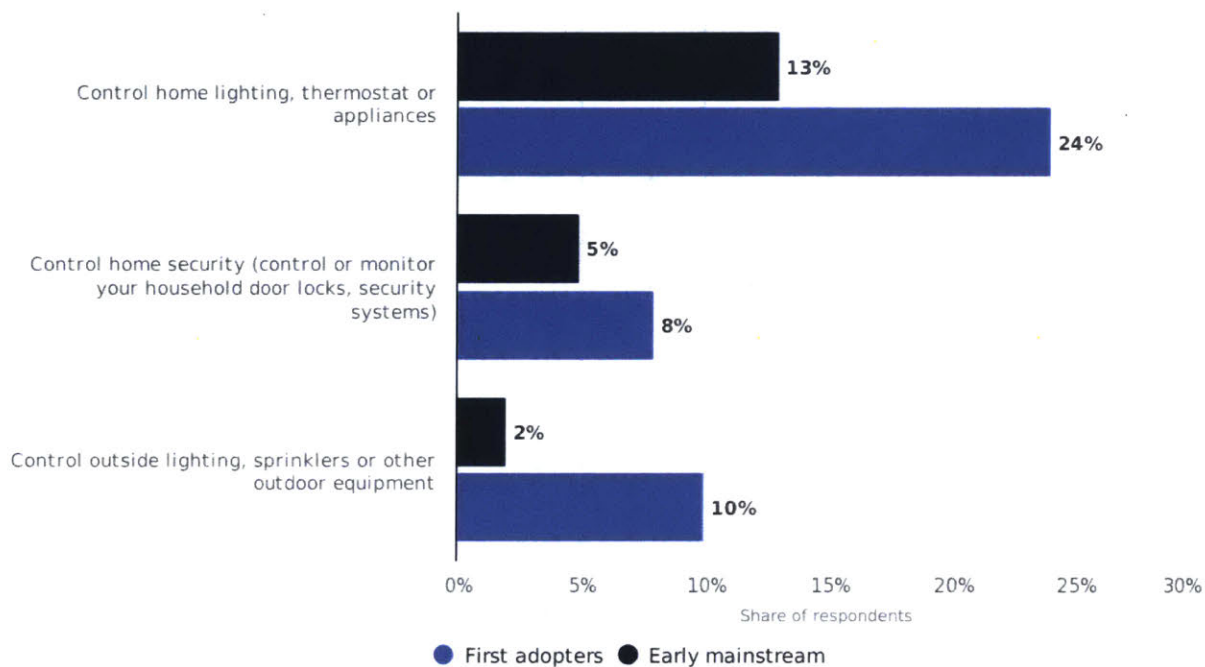
* category was limited to "playing games" in Q1 2017 survey
Base: U.S. households owning at least one smart speaker
Source: comScore

statista

Figure 7 Smart Speaker Use Cases

If we then drill into for example tasks that are specific to the home, we see that controlling lighting, thermostats, and appliances have the highest share of respondents followed by functions relating to home security.

Smart speaker's smart home capabilities usage rate in the United States in 2018



Sources
Edison Research, NPR
© Statista 2018

Additional Information:
United States; May 21st to June 1st 2018; 909 respondents; 18 years and older, U.S. smart speaker owners

statista

Figure 8 Smart Speaker Capability Usage Rate

These survey results line up correspondingly with the primary user needs in the home. In the context of being able to accomplish tasks in the home, screen-based device queries remain one of the most tedious mediums for users as query generation via typing on a screen is much slower than voice. This problem is confounded by the fact that not all users have the dexterity to type as well as they can articulate their query using voice – this is true especially for users who are older and may not be as savvy with technology. Additionally, tasks such as setting a timer, or looking up a recipe become much more natural in environments such as the kitchen where users often have their hands occupied or cannot use a display-based device. Thus, voice becomes a natural modality to meet these needs.

The next need centers around a better understanding of the user's home and its attributes. Being able to understand which appliances are running, and their current status becomes much more natural when queryable through voice. In fact, with the rise of IoT and smart appliances, voice

can be a necessary modality where digital assistants can let users know when particular appliances may fail and preempt repairs. Voice can be a particularly good modality to transmit this information where the temporal nature of failure requires immediate attention (e.g. a push notification sent to the user's email may not be the most appropriate signal for a grease fire that just broke out in the kitchen as voice would be much better in this situation). Another common use case involves being able to multi-task through voice wherein a user can adjust the temperature or lighting in another room while in another part of the house, or indeed elsewhere. For example, a parent who has just pulled into the driveway on his way home from work can instruct the assistant on their smartphone to set the thermostat to a comfortable temperature as well as to turn the living room lights on, all while driving home. This is tremendously useful and improves the quality of life of users.

The final need is one of convenience. As digital assistants improve in their natural language understanding, they will be able to understand the small subtleties in our voice commands that cannot be communicated currently through touch or display based modalities. For example, ambient intelligence from a digital assistant in the home may be able to sense when temperature needs to be raised and can preemptively ask users if they are cold based on physical and proprioceptive cues. Taken a step further, digital voice assistants can, for example, even detect a child crying and immediately alert parents that the child may need to be attended to. There are key signals and idiosyncrasies that can be captured through voice interaction to provide an even richer digital assistant experience.

It is important to address the reality that voice will not wholly replace displays for smart assistants – rather voice will be a complementary modality to visual-based interaction using displays. Some tasks are simply better suited to being accomplished through visual and touch based displays. An example would be that while it's more convenient for a user to yell out to Google Assistant to find a recipe for chicken marsala if their hands are occupied, it's better if Google Assistant displays the recipe and only announces the first step rather than going into a long rambling discourse on every step of the recipe (which is what many of the voice assistants currently do). As digital voice assistants continue to diffuse into the mainstream, it's critically important for digital assistant designers and engineers to balance voice and visual modalities.

Key Players’ Strategies

Evaluating Digital Assistant Strategies

In the following sections, each of the major players’ core business models and current strategies will be presented first. Using their broader company strategy as a basis, each of these key players’ current strategies for digital voice assistant will then be presented, through an analysis of what their primary stakeholders value. Specifically, a technique called stakeholder value mapping will be employed to understand qualitatively how each digital assistant is, or is not, delivering value to the two most important key stakeholder groups: consumers and developers. Finally, these analyses will form the basis for recommendations on what should be the key players’ future strategies for digital voice assistants.

For consumers, definitions of their stakeholder values are listed below. In particular, the values are listed in order of an expected customer journey including discovery, evaluation, and adoption of their digital assistant:

Stakeholder Group: Consumers	
Company	
Value	Definition
Privacy and Trust	Trustworthiness and ability to protect users’ privacy
Ease of Assistant Access	Availability of assistant on a wide range of devices in the home
Accomplish First Party Tasks	Ability to perform reliably on first party tasks
Integrate with Third Party Apps	Ability to integrate third party apps with assistant
Integrate with Core Company Competencies	Assistant ability to integrate with existing company’s core applications and services

For developers, definitions of their stakeholder values are listed in order of typical considerations during the voice application development process:

Stakeholder Group: Developers	
Company	
Value	Definition
Voice App Creation Tools	Company support of voice app creation
Ease of App Distribution	Ability for developers to distribute their voice apps
App Discovery and Promotion	Ease of app discovery and promotion for consumers
Monetization Opportunities	Availability of monetization opportunities for third party app developers
Integration with other Third Party Smart Home Devices	Ability to integrate assistant with other hardware device makers

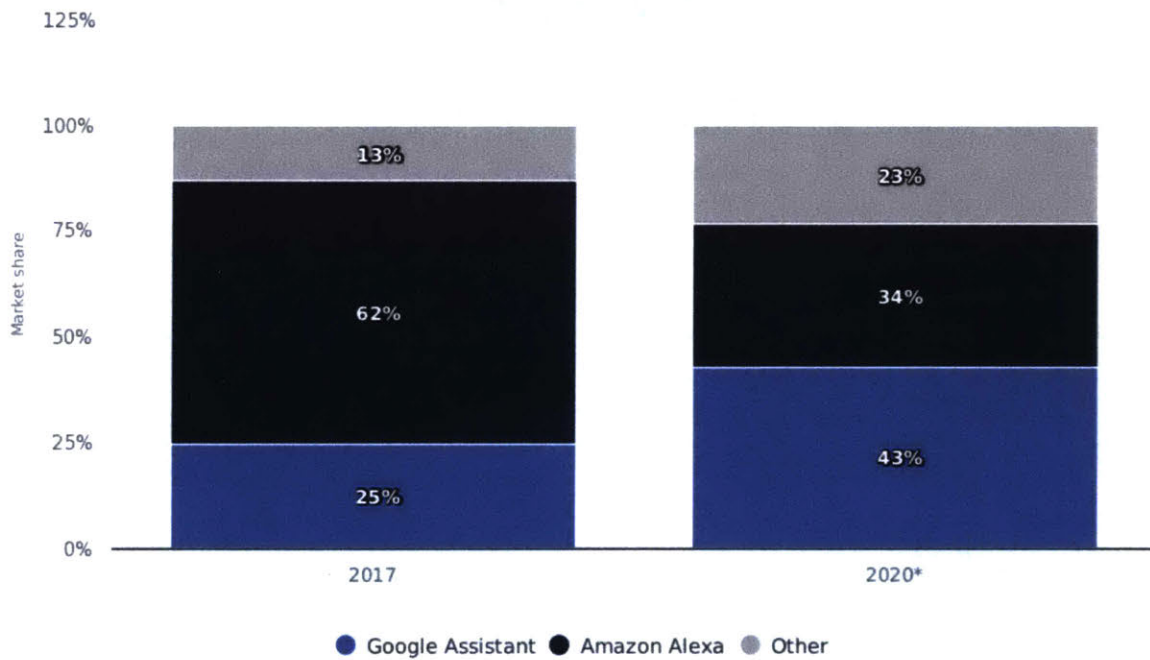
Amazon

Amazon’s business model and strategy can be summed up as being the “everything” store for consumers. While it began in 1994 as an online bookstore, it has since expanded to everything from physical retail, to groceries, to cloud computing, and even digital advertising. In addition to being an accessible destination for sellers and consumers to transact online, Amazon has continually touted its strategy to always focus on new ways to delight its customers across all of its portfolio of products and services, what it calls ‘Day 1’; as described by CEO Jeff Bezos, “Day 1” has evolved to become a key tenet of Amazon’s company strategy and it essentially represents the mentality that every day, every product, every business decision represents “Day 1” (Bezos, 2017). This means that there is an obsession at Amazon to continually focus on new ways to delight its customer, it openly embraces broader macro trends, and it makes high quality decisions quickly.

Based on this foundational understanding of Amazon’s broad company level strategy, Alexa can then be viewed through a similar lens. Alexa is currently the leading digital voice assistant in

terms of installed base. Alexa burst onto the scene in November of 2014 and surprised almost everyone with a new hardware device, the Amazon Echo, powered by the intelligent assistant Alexa. Amazon then poured in a significant amount of resources with over 10,000 employees working on Alexa, Echo, and related devices as of 2018 (MacMillan, 2018). In recent years, we have seen Alexa become a core part of Amazon’s strategy as its “Alexa everywhere” campaign was prominently displayed at the most recent CES 2019 show in Las Vegas. With the introduction of the aggressively priced Echo device coupled with the fact that it enjoyed a significant first-mover advantage over Google Assistant and Apple HomePod, Alexa has propelled into the lead and as of 2017, Alexa commands over 62% of the worldwide market share in for intelligent digital assistants according to IHS.

Worldwide intelligent/digital assistant market share in 2017 and 2020, by product



Source
IHS
© Statista 2018

Additional Information:
Worldwide; 2017

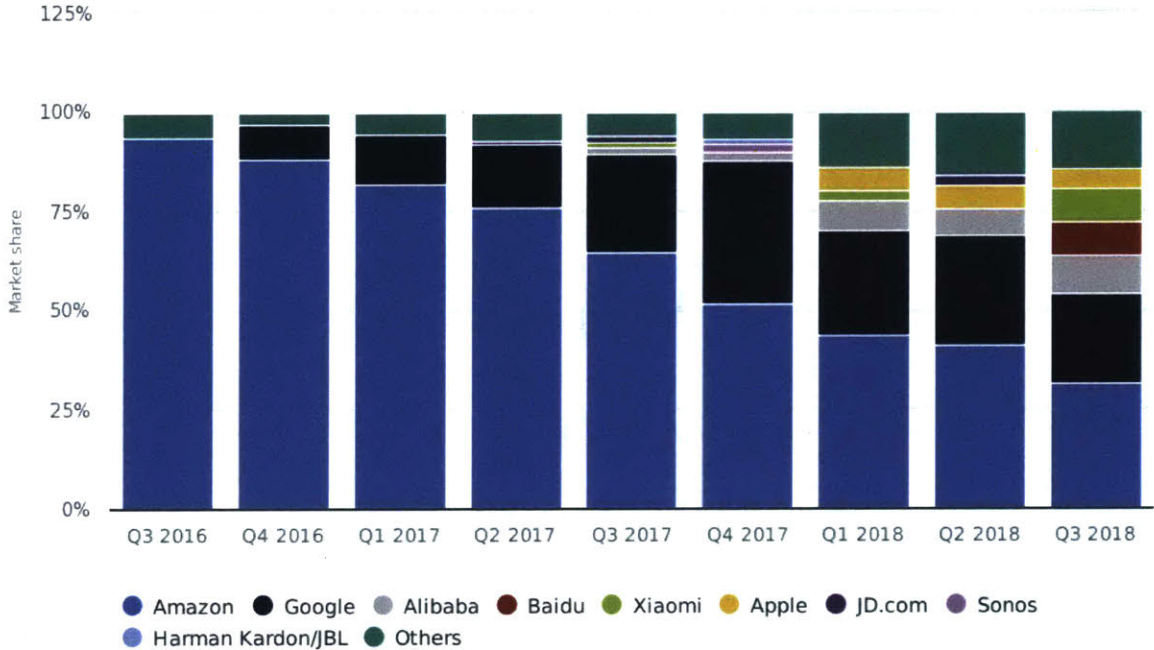
statista

Figure 9 Worldwide Assistant Market Share

However, one key statistic to note is that by 2020, Alexa is predicted to lose its lead in market share as Google, with the introduction of its smart speaker device, Google Home, in 2016 is quickly catching up in market share (more on Google Assistant below). If we drill down and

focus on the smart speaker segment in which Alexa currently operates we do see that Alexa is gradually losing its market share after debuting Alexa on the Amazon Echo device a few years back.

Smart speaker with intelligent personal assistant quarterly shipment share from 2016 to 2018, by vendor



Source: Strategy Analytics © Statista 2019

Additional Information: 2016 to 2018

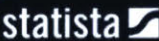


Figure 10 Intelligent Assistant Shipment Share by Vendor

Amazon pursued a strategy to ensure Alexa was inserted into as many places as possible, partnering with smart device makers, technology companies such as Microsoft (who actually develop their own competing digital assistant known as Cortana), and sold their echo devices with Alexa for as little as \$30.

In order to gain a deeper understanding of Amazon’s Alexa strategy, it is instructive to perform a stakeholder value exchange assessment with both consumers and with developers. The following will help elucidate what consumers and developers value from Amazon, and from its Alexa assistant product.

Stakeholder Group: Consumers		
Amazon Alexa		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Ease of Assistant Access	5	3
Accomplish First Party Tasks	5	2
Integrate with Third Party Apps	4	5
Privacy and Trust	4	2
Integrate with Core Amazon Competencies (e.g. E-commerce, Prime)	3	4

Table 1 Alexa Consumer Stakeholder Values

Based on these core stakeholder values, we then build a stakeholder value map to visualize how well Alexa is meeting the needs of its consumer stakeholders. Stakeholder maps visualize which stakeholder values are being met with respect to its relative importance to the stakeholder. This map can then be used to inform which areas could be targeted for improvement in order to better meet stakeholder needs.

Alexa Consumers

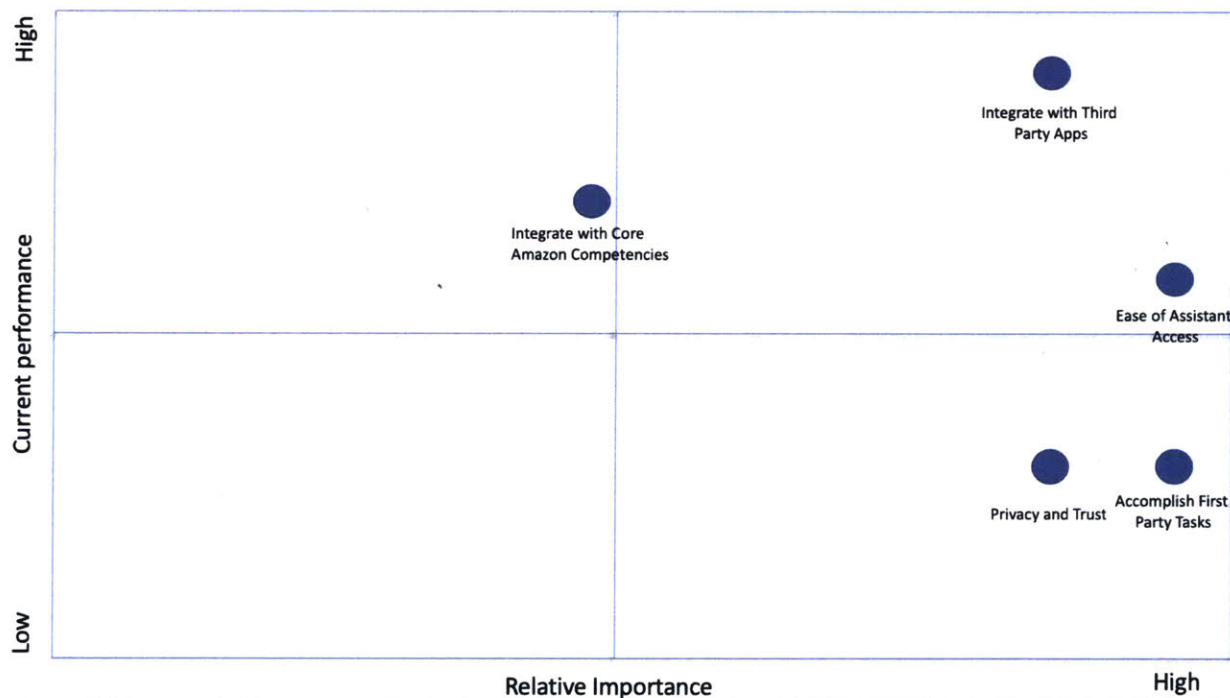


Figure 11 Alexa Consumers Stakeholder Value Map

A similar stake holder value analysis can be performed for third party Alexa developers as well.

Stakeholder Group: Developers		
Amazon Alexa		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Voice App Creation Tools	4	4
Ease of App Distribution	4	5
Monetization Opportunities	5	1
Integration with other Third Party Smart Home Devices	3	4
App Discovery and Promotion	5	2

Table 2 Alexa Developers Stakeholder Values

Alexa Developers

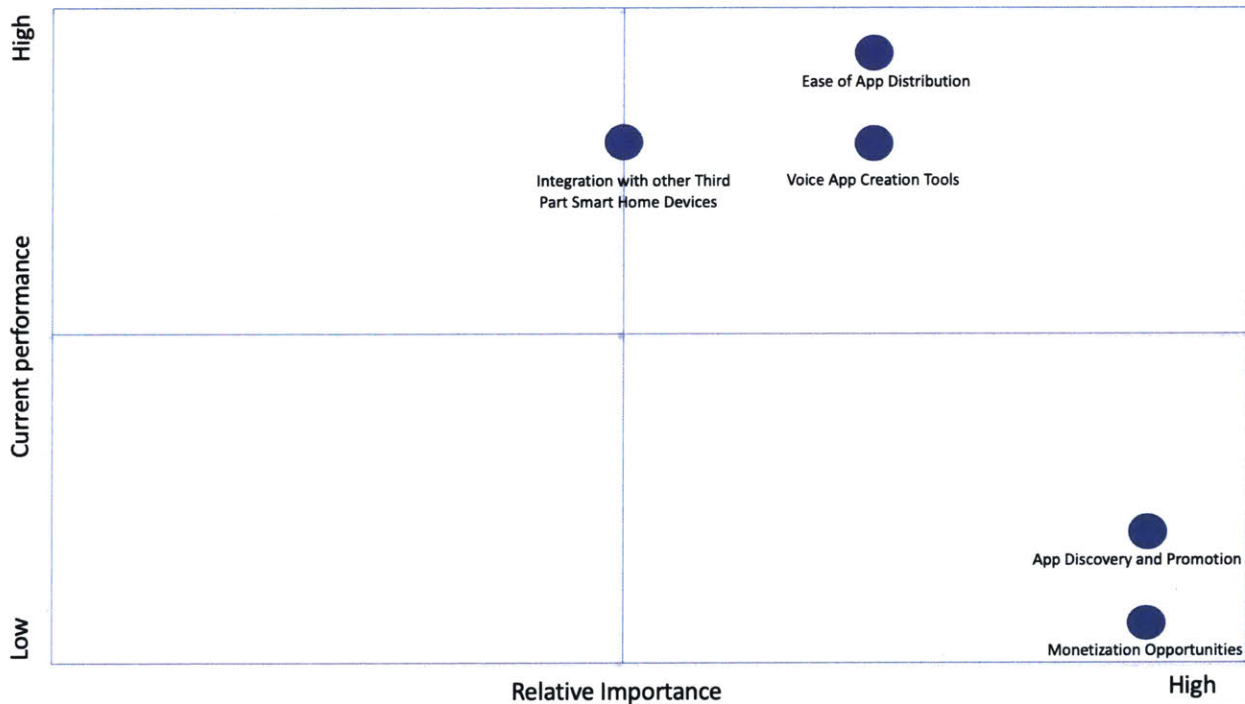


Figure 12 Alexa Developers Stakeholder Value Map

From these analyses, we see that Alexa is doing a great job on both fronts for consumers and developers, especially in developer ease of app creation and distribution. This makes sense since

Amazon has poured enormous resources into Alexa compared to its competitors. Amazon was able to beat Google and Apple in the race to bring a consumer smart speaker device to market, and then continued to fuel its market share through aggressive device pricing. Furthermore, Amazon has been the most proactive in fostering third party voice app development in addition to making its Alexa enabled devices as widely accessible as possible. Consequently, Amazon has enjoyed a leading market share and the largest install base in smart home digital assistants.

Tying its Alexa strategy back to Amazon's core business strategy, which has been to ensure that it remains the primary platform for e-commerce, we see that Amazon's Alexa strategy then helps reinforce this core strategy in three specific ways. First, since Amazon does not have any other avenue for its assistant to penetrate into the consumer home by way of smartphones or other hardware devices, Amazon made a significant play to build out its Alexa-powered device line up. The Echo hardware lineup boasts over ten devices now and by vertically integrating Alexa into its own hardware products, it has been able to own the entire supply chain and price at or below cost to boost its market share.

Second, Amazon has engaged in partnerships with other hardware makers by integrating Alexa on a wide variety of platforms and devices ranging from other (competing) smart speakers, to automobiles, and in smart home devices such as thermostats and appliances. Indeed, Amazon has even partnered with Microsoft to allow cross-integration with Cortana (more on this below in the Microsoft section).

Finally, Amazon has decided to embrace an open platform approach by allowing nearly any developer to develop applications for Alexa, known as 'skills'. An open-platform strategy is one in which a platform provider, such as Alexa, allows any third-party developer to operate on its platform, often times with minimal oversight yet providing incentives for developers to do so, in order to build a strong base on multiple sides of the platform in order to drive network effects. Amazon has also started the Alexa Fund, an investment vehicle meant to fuel voice technology innovation amongst third-party developers. In pursuing these strategies, Amazon has amassed over 50,000 available skills for Alexa in the United States alone.

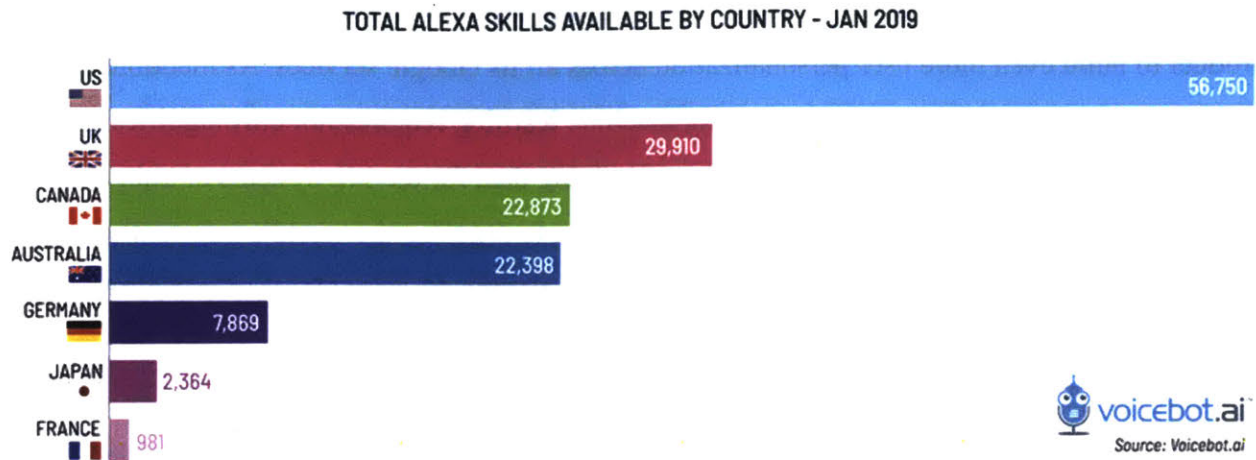


Figure 13 Total Alexa Skills

This means that essentially, there are over 50,000 different applications that leverage Alexa to accomplish tasks. This is an incredibly diverse platform for users but discoverability remains a challenge for those skills; as a user, how do they know what skills are available? We see that Alexa continues to embrace the open platform strategy by now allowing anyone to publish a skill without explicit Amazon approval (Crum, 2019). It's clear that Amazon wants Alexa in the hands of as many developers and consumers alike. Whether or not this strategy is sustainable and how they can convert a large install base into a meaningful advantage that fuels their core business remains to be seen.

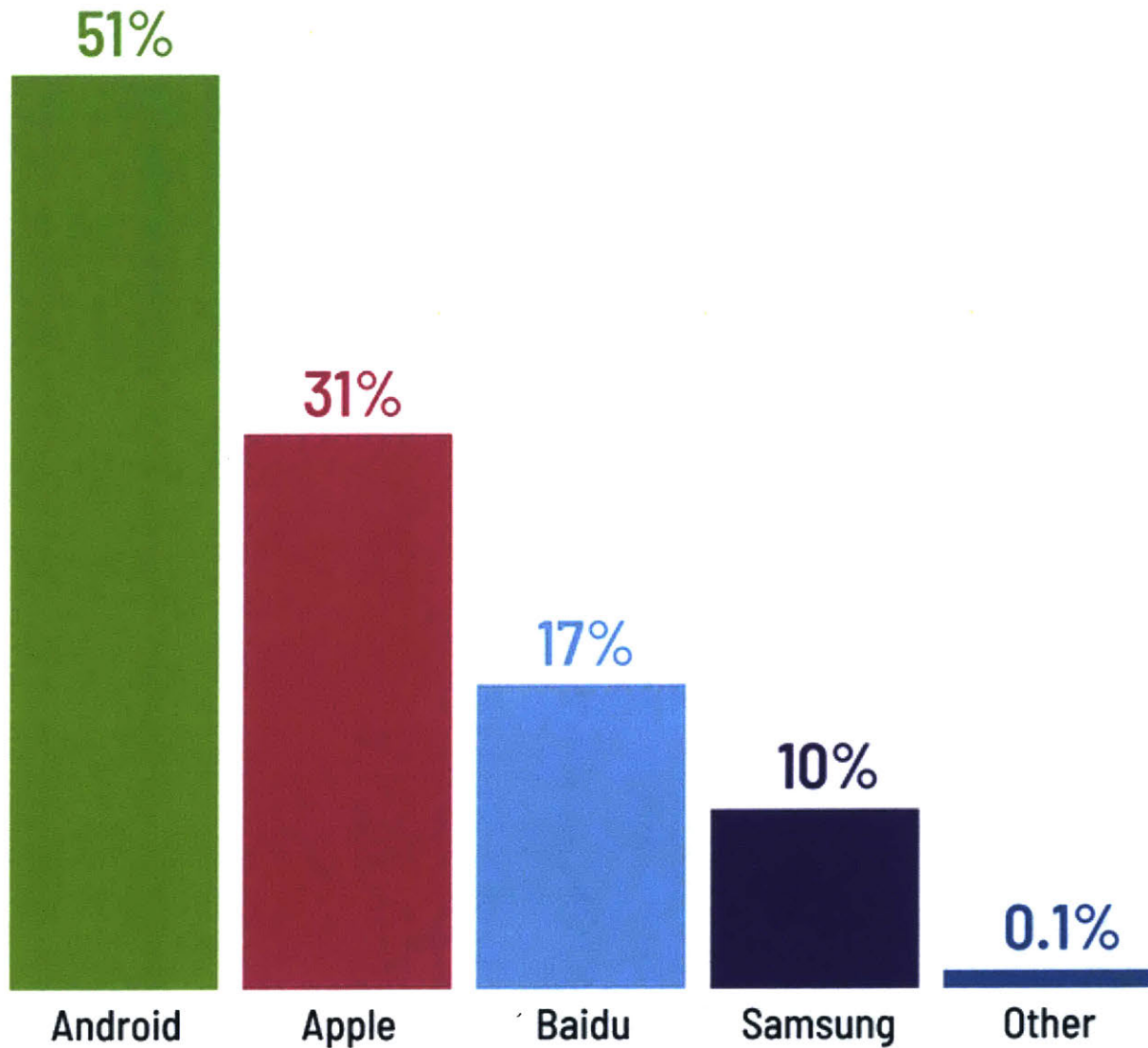
Google

Google, with roots in online search, makes the vast majority of its revenues from its digital advertising business – in fact over 85% of Google's revenue comes from advertising on Google sites or Google Network affiliated sites (Statista, 2018). The Google advertising business itself has generated enough revenues for Alphabet (Google's parent company) to engage in what it calls "other bets" or "moonshots". These are other ventures that do not necessarily generate a profit for Alphabet but instead are ventures that Alphabet believes are important to invest in for the future (Alphabet, 2019). A number of these "other bets" have become successful companies, such as the self-driving company Waymo. Google's broader company-wide strategy then can be summed up as the following: in 2017 Google CEO Sundar Pichai claimed that the company has moved on from a mobile first strategy to an "AI-first" strategy (Google, 2017). This means

incorporating artificial intelligence and machine learning technologies in nearly every Google product to build even more user personalization across all its Google services. As mentioned previously, the key to successfully leveraging machine learning requires not only significant amounts of data but also tremendous varieties of training data for the ML systems to train and learn from. Because Google's mission had already been to organize the world's information, it has deep AI capabilities and is one of the leaders in developing AI technologies especially as it leverages innovations from other Alphabet holdings such as DeepMind.

The release of Google Assistant was in many ways quite similar to Amazon Alexa. Google Assistant was announced in May of 2016 and launched in November of 2017 on the Google Home smart speaker. However, because of Google's large existing installed base of Android smartphones worldwide, Assistant began rolling out on Android operating systems starting with the Android Marshmallow and Nougat operating system versions in early 2017. Google's strong installed base of over one billion (Bohn, Google Assistant will soon be on a billion devices, and feature phones are next, 2019) Android devices has helped bring its digital assistant to more users than any other major vendor in the intelligent personal assistant space.

Global Smartphone Virtual Assistant Penetration - 2018



Source: Strategy Analytics



Figure 14 Global Smartphone Virtual Assistant Penetration

Shortly thereafter, Assistant became available on numerous Google hardware devices and eventually on non-Google devices as well such as smart displays developed by Sony and Lenovo. Assistant also enjoys strong developer support, including for example the release of a software development kit for hardware makers in April of 2017.

Google’s Assistant strategy is then to integrate Assistant into as many products as possible in hopes of collecting as much user data as possible to make Assistant smarter and even more personalized. Research shows that Assistant has a distinct advantage in terms of having the highest “IQ” as defined by Loup Ventures. The figure below comes from a study where each Assistant was asked a series of question and graded on understanding and ability to answer accurately, and in which Google Assistant is graded as the “smartest” Assistant.

Query Results

	Answered Correctly	Understood Query
Google Assistant	87.9%	100%
Siri	74.6%	99.6%
Alexa	72.5%	99.0%
Cortana	63.4%	99.4%

Figure 15 Assistant Query Study Results

The stakeholder value analysis for Google Assistant consumers and developers are as follows.

Stakeholder Group: Consumers		
Google Assistant		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Ease of Assistant Access	5	4
Accomplish First Party Tasks	5	4
Integrate with Third Party Apps	4	4
Privacy and Trust	4	2
Integrate with Core Google Competencies (e.g. Gmail, Search, Calendar)	4	4

Table 3 Google Assistant Consumer Stakeholder Values

Google Assistant Consumers

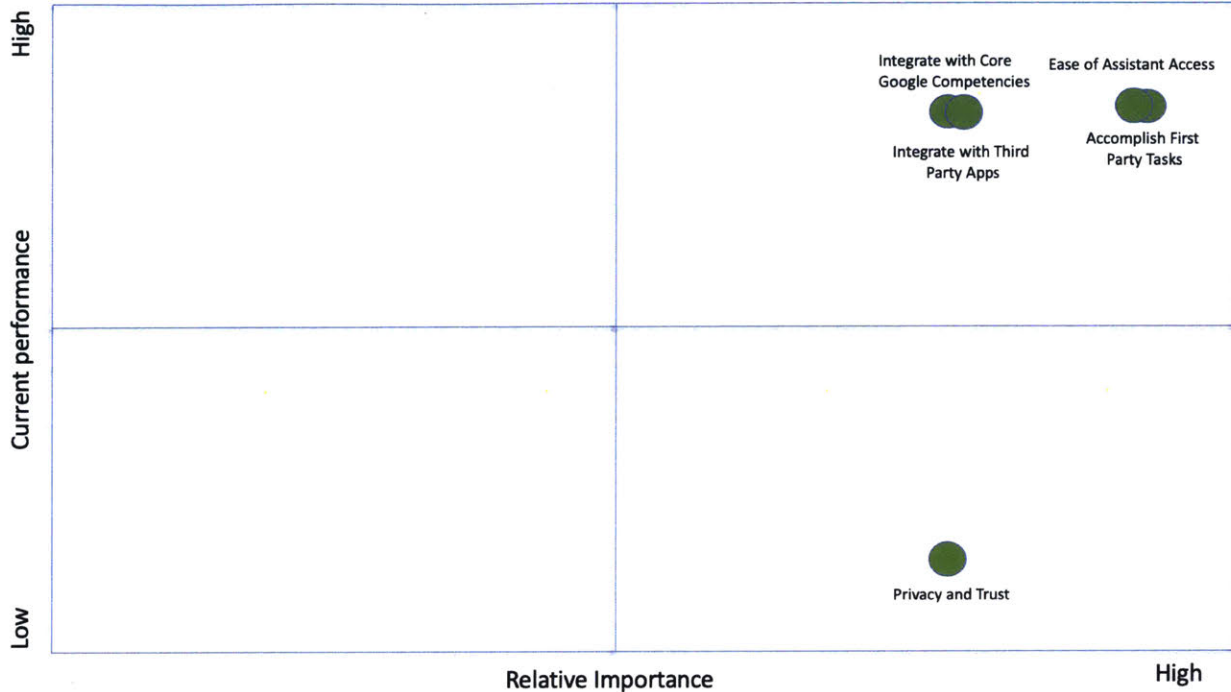


Figure 16 Google Assistant Consumers Stakeholder Value Map

We see here that Google has done well in building a formidable competitor that meets many of its consumer needs although privacy and trust remain a huge issue for Google Assistant. For a company that heavily relies on targeted advertising to drive most of its core revenues, it makes sense that Google needs to build out a strong profile of their users' digital habits. However, as stated previously, companies that rely on advertising to users can be perceived as not having the users' best interest at heart regarding data privacy given the inherent conflict of interest between generating maximum advertiser revenue and not divulging too much relevant user data. We see in the following exhibits that Assistant developer stakeholder performance is not as strong compared to Alexa.

Stakeholder Group: Developers		
Google Assistant		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Voice App Creation Tools	4	3
Ease of App Distribution	4	3
Monetization Opportunities	5	1
Integration with other Third Party Smart Home Devices	3	3
App Discovery and Promotion	5	2

Table 4 Google Assistant Developer Stakeholder Values

Google Assistant Developers

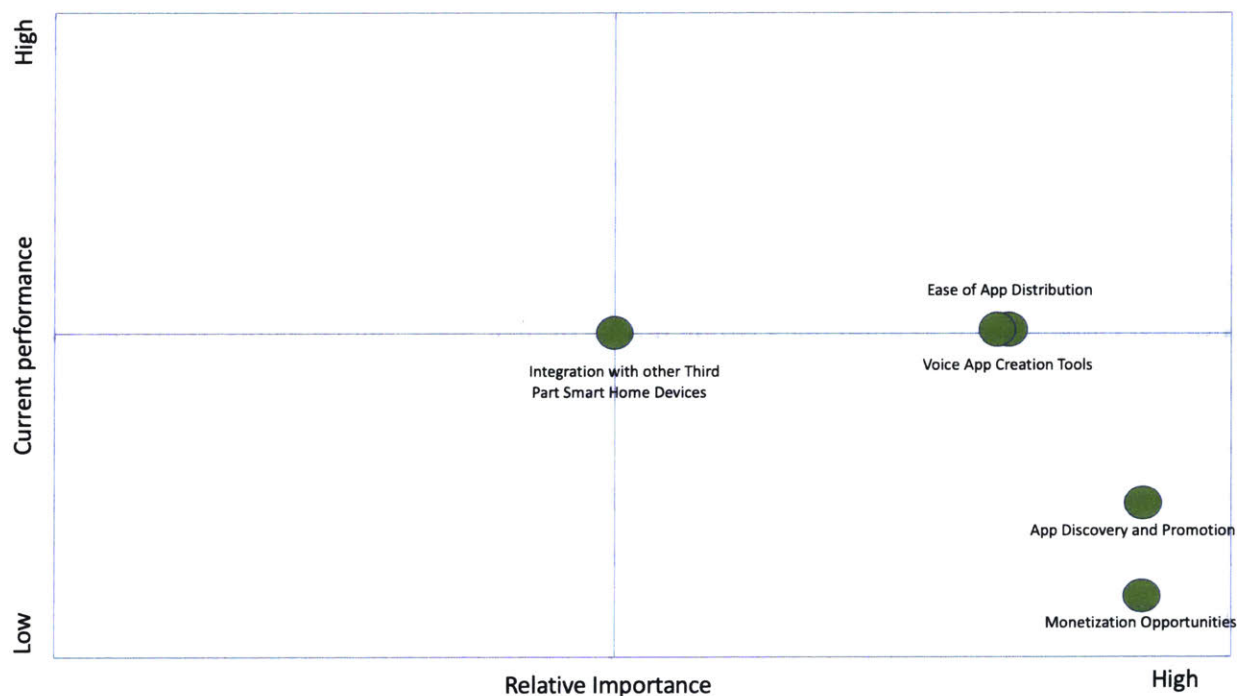


Figure 17 Google Assistant Developers Stakeholder Value Map

Much like Alexa, Google Assistant has put forth a compelling product for consumers driving considerable demand despite joining the party late. In fact, Google Assistant may be the superior product from a technical and commercial standpoint because of Google’s deep expertise in AI and ML systems that can provide a cohesive user experience across its many products and

services. We see this manifested in the fact that Google scores strongly in meeting most of its consumer stakeholder values which in turn helps it to gather more data to understand their customers even better. However, also similar to Alexa, Google Assistant needs to find ways to incentivize and promote more developers to develop on Google Assistant to build out a compelling ecosystem.

While Assistant's strategy may be similar to Alexa's in that they both hope to penetrate widely in the consumer home market, being integrated in both devices native to Google and Amazon respectively, as well as third party hardware device makers, Assistant's end-goal is to be as personalized as possible and to know as much as possible in order to build out a complete profile of consumer behaviors when using Google's products. This may help drive online purchasing behavior similar to Alexa but Assistant's strategy may be broader in understanding user preferences beyond shopping, and in particular goes well beyond the scope of activities that are central to Amazon's business model. Perhaps this could include knowing where users vacation, which restaurants they eat at, what YouTube videos they watch, and all of the data from these domains will be used to make Google Assistant even more personalized.

Google has deep expertise in artificial intelligence and machine learning capabilities so that its foray into the home with Assistant arrives with incredible momentum as they battle for market share in order to become not just your personal shopping assistant, but your personal assistant for everything. This will allow Google to evolve its core business model in digital advertising as consumers move away from text-based search engines and more into voice.

Apple

Apple's business model derives much of its revenues from the sales of its Mac, iPad, and iPhone products. In fact, those three products make up over 78% of Apple's revenues (Statista, 2019). However, believing that Apple is 'just a hardware product company' does not consider sufficiently the reality that what makes Apple products so compelling is its vertically integrated software and hardware ecosystems that deliver outstanding and seamless user experiences, that lock customers in. Apple's customers are among the most loyal, with iPhone retention rates over 90% (Morgan Stanley, 2017) and Apple's strategy has focused on building an ecosystem that

keeps its users using Apple services such as Apple Music and iCloud within this ecosystem and purchasing even more Apple products as they become available such as the Apple Watch.

Siri, the first commercially available intelligent personal assistant was introduced in 2012. Despite Steve Jobs wowing the audience at Apple’s keynote announcing Siri for the iPhone, since the announcement reality has not yet fully caught up with expectations for Siri as public perception has been that Siri is the weakest of the major digital assistants. In 2014, Amazon’s release of Alexa on the Echo device took Apple by surprise and kicked off an arms race in the digital assistant market. Not one to cede this market, Apple has recently re-devoted efforts to its Siri and broader AI/ML strategy. Most notably, Apple hired John Giannandrea, the former chief of Search and Artificial Intelligence at Google, in 2018 to oversee machine learning and artificial intelligence at Apple (Jack Nicas, 2018). This was an indication that Apple was serious about its AI strategy and quickly moved Siri under John’s leadership. While typically Apple stays mum about its product strategy, it is clear that Siri is now a focus for it as it has continued to devote resources to improving Siri as it has become a core product that lives on most if not all Apple devices.

Recent benchmarks have seen marked improvement in Siri’s ability to answer queries.

Query Results

	Answered Correctly		Understood Query	
	Apr-17	Jul-18	Apr-17	Jul-18
Google Assistant	74.8%	85.5%	99%	100%
Siri	66.1%	78.5%	95%	99%
Cortana	48.8%	52.4%	97%	98%
Alexa	n/a	61.4%	n/a	98%

Figure 18 Improvements in Query Results (Loup Ventures)

Apple’s Siri strategy however is significantly different than its two other major competitors. Apple has rarely been the first to market for many of its most innovative products but when it finally does release a product, Apple has been known to “get it right” and to position itself as

building beautiful, high quality products that just “magically work” in the Apple device ecosystem. It seems that Apple is taking the same approach here with Siri, electing to forgo allowing Siri on any third-party devices (to date, Siri is only available on one smart speaker device, the HomePod) beyond its core set of Apple devices on iOS, macOS, watchOS, and tvOS.

Apple, however, has embraced a closed but open platform strategy in allowing third party developers to work with Siri. In this platforming strategy, Apple had initially decided to allow only a subset, rather than any third-party developer, to integrate Siri through the SiriKit software development kit. Similarly, HomeKit, enables certain hardware developers to create apps to control smart-home appliances and have been recently enabled to work with Siri. However, the lineup of devices that can be supported by HomeKit remains low as custom Apple approved hardware was required to integrate Siri. Consistent with its long-standing need for control, Apple has strict requirements on how and where Siri can be integrated on third-party devices.

The stakeholder analysis for Apple’s digital assistant, Siri, is found below.

Stakeholder Group: Consumers		
Apple Siri		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Ease of Assistant Access	5	4
Accomplish First Party Tasks	5	3
Integrate with Third Party Apps	4	2
Privacy and Trust	5	4
Integrate with Core Apple Competencies (e.g. iOS, macOS, Apple Music)	5	4

Table 5 Apple Siri Consumers Stakeholder

Apple Siri Consumers

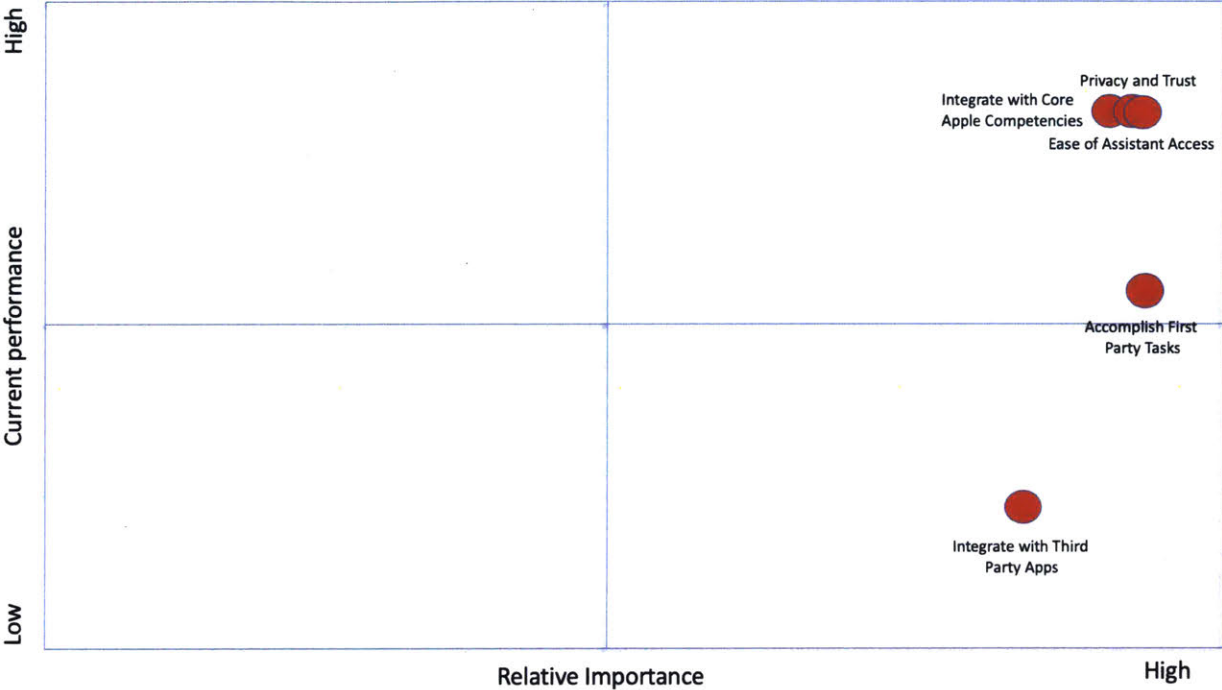


Figure 19 Apple Siri Consumers Stakeholder Value Map

While Apple has done well to earn the trust of its most loyal consumers, Siri still struggles from a technical standpoint, even on Apple’s own first-party services. Furthermore, Siri has limited ability to integrate with other third-party apps and can only do so through SiriKit or HomeKit as mentioned previously. Apple’s third-party developer stakeholder analysis is even more dire compared to its competitors.

Stakeholder Group: Developers		
Apple Siri		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Voice App Creation Tools	5	2
Ease of App Distribution	4	1
Monetization Opportunities	5	1
Integration with other Third Party Smart Home Devices	4	2
App Discovery and Promotion	5	1

Table 6 Apple Siri Developers Stakeholder Values

Apple Siri Developers

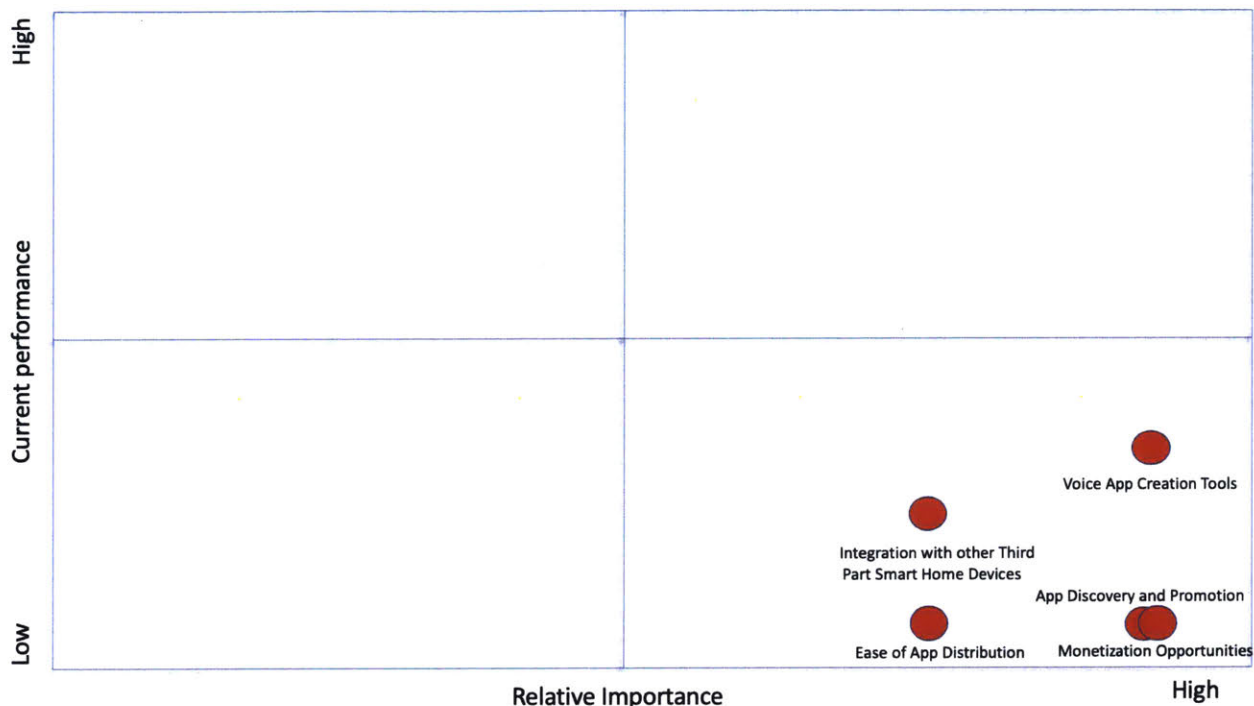


Figure 20 Apple Siri Developers Stakeholder Value Map

We see that Apple’s Siri remains tightly controlled and the number of third-party developers are fewer than compared to Alexa or Assistant. Apple’s ‘wait and see’ approach, letting competitors experiment first remains key to its digital assistant strategy.

Taking a deeper dive, there are two key points to note about Apple’s strategy with Siri. First, Apple understands that the digital assistant space is still young and the race has just barely begun. Core to its mission of delivering the best products to its users, Apple is content to let other digital assistants and hardware device makers flood the market in an experimentation effort. A battle to the bottom in terms of pricing is not what Apple wants to be engaged in and does not align with Apple’s broader core strategy of producing high quality products that complement each other within the Apple device ecosystem. Thus, Apple understands that it needs to invest in Siri and as long as Siri is not drastically worse than the other assistants, and Apple does not see users begin to defect from the Apple ecosystem, it remains content with a wait-and-see approach. Apple’s assistant strategy is to choose carefully how and when to invest rather than trying to invest in everything and seeing what “sticks”. This is evidenced by Apple’s previous history in releasing products where it was rarely the first to market.

Secondly, Apple has a deep commitment to user privacy and goes to great technological lengths to obfuscate user data. This presents challenges in machine learning technologies where vast amounts of data enable smarter and more personalized understanding and recommendations. Furthermore, much of the processing for Siri happens on-device so that the personal user data never even reaches Apple's servers. The idea is that if Apple does not see or have the user data, then the data cannot be misused. Apple's privacy stance, while admirable, has in some ways put it in a huge disadvantage when it comes to machine learning technologies that Siri relies on. Nonetheless, Apple believes that it can build an intelligent personal assistant without compromising user security. Apple's redevelopment efforts on Siri has gained steam in recent years with clear competition from the likes of Google Assistant and Amazon Alexa. With a deep installed base of Apple hardware devices, Siri still remains the most used digital assistant (see figure below) but that lead may be shrinking if Apple does not continue to innovate and improve Siri to keep up with the competition.

Voice Assistants Used on Smartphones

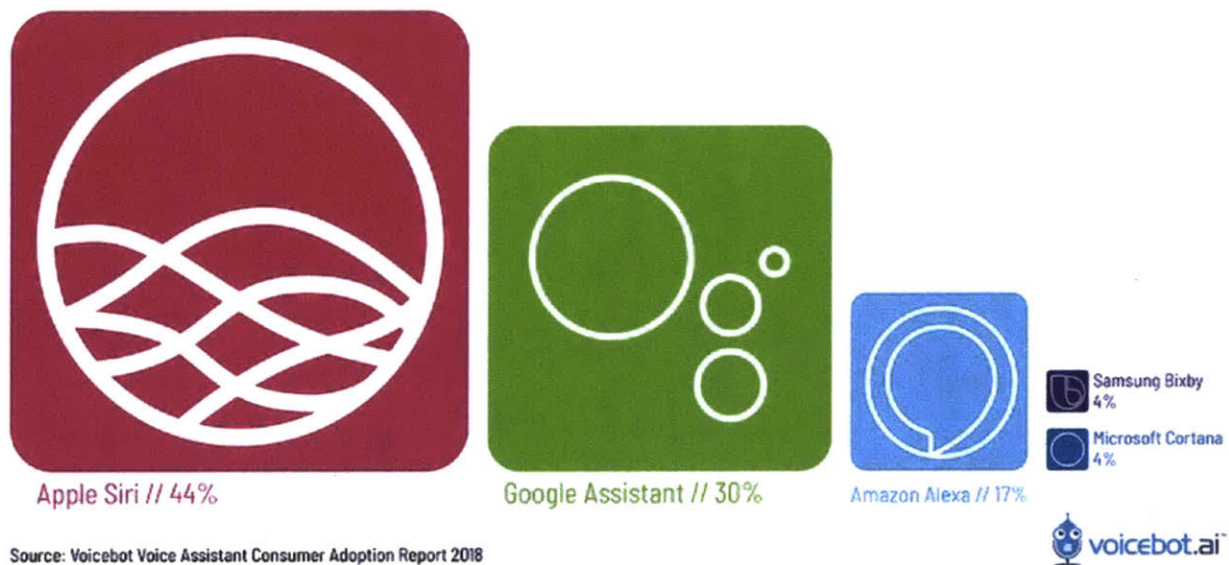


Figure 21 Voice Assistants Usage on Smartphones

It remains to be seen whether Apple will pursue a smart-home only strategy or continue to rely on its deep penetration of smartphone devices and complementary Apple products. Apple would be wise to utilize both.

Microsoft

Microsoft, a leader in the personal computing space has repositioned itself most recently as an enterprise software company. With the rapid growth of its cloud computing and business products contributing a significant portion of their revenue, Microsoft is now in a unique position having been a keystone player in the personal computing world for many decades. Microsoft's foray into the digital assistant market began with Cortana in April of 2014. The initial concept and inspiration for Cortana was based on human personal assistants and Cortana retains many features gleaned from those interactions including the concept of Notebook, which is an index of personal information related to the user including reservations, names, dates, reminders, and contacts. Microsoft's original strategy was also similar to that of the other assistants in trying to get Cortana on as many hardware devices as possible. This made sense since Microsoft had a robust consumer hardware device business including the popular Xbox gaming platform. However, beginning in 2017, their Cortana digital assistant strategy took an interesting turn.

Before we delve further into Microsoft's Cortana strategy, a similar stakeholder analysis will be performed to understand its initial assistant strategy.

Stakeholder Group: Consumers		
Microsoft Cortana		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Ease of Assistant Access	4	1
Accomplish First Party Tasks	4	2
Integrate with Third Party Apps	4	1
Privacy and Trust	3	3
Integrate with Core Microsoft Competencies (e.g. SkyDrive, Outlook)	5	4

Table 7 Microsoft Cortana Consumers Stakeholder Value

Microsoft Cortana Consumers

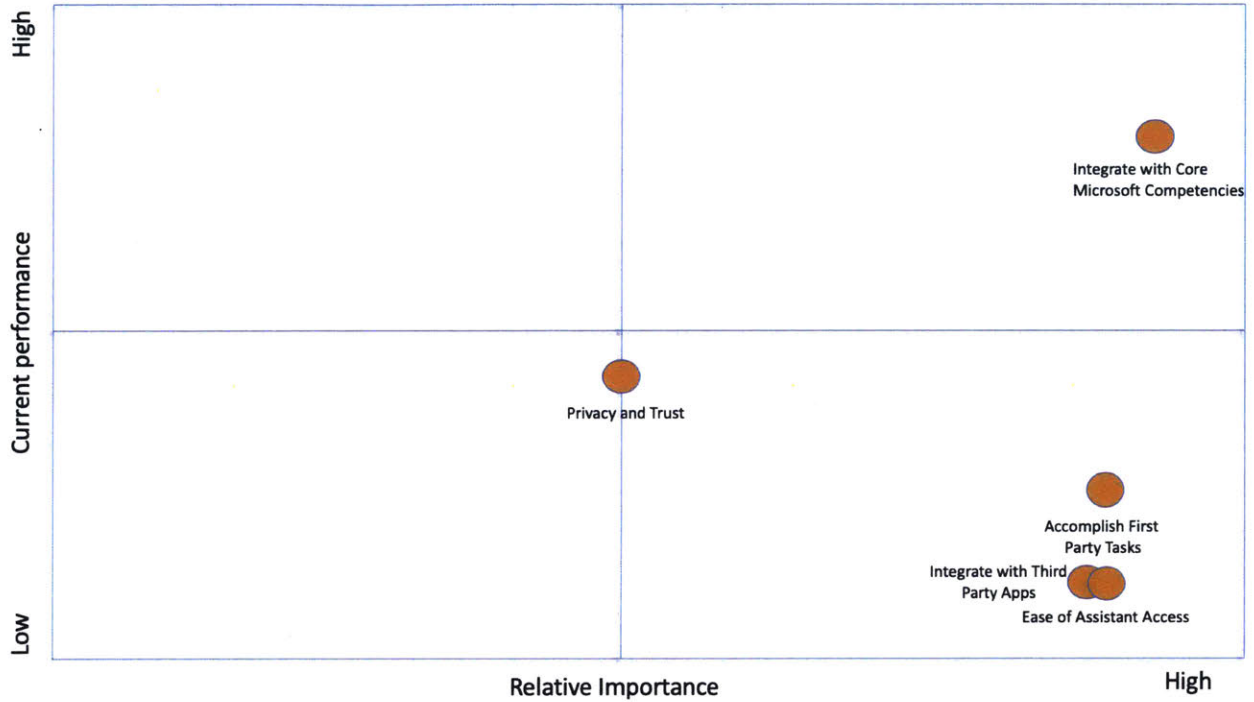


Figure 22 Microsoft Cortana Consumers Stakeholder Value Map

Foreshadowing Microsoft’s consumer digital assistant strategy, we see that Microsoft had low performance across the major stakeholder values except for integration with its Microsoft suite of products. A similar trend can be seen in its developer strategy as well.

Stakeholder Group: Developers		
Microsoft Cortana		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Voice App Creation Tools	4	2
Ease of App Distribution	4	1
Monetization Opportunities	5	1
Integration with other Third Party Smart Home Devices	4	3
App Discovery and Promotion	5	1

Table 8 Microsoft Cortana Developers Stakeholder Values

Microsoft Cortana Developers

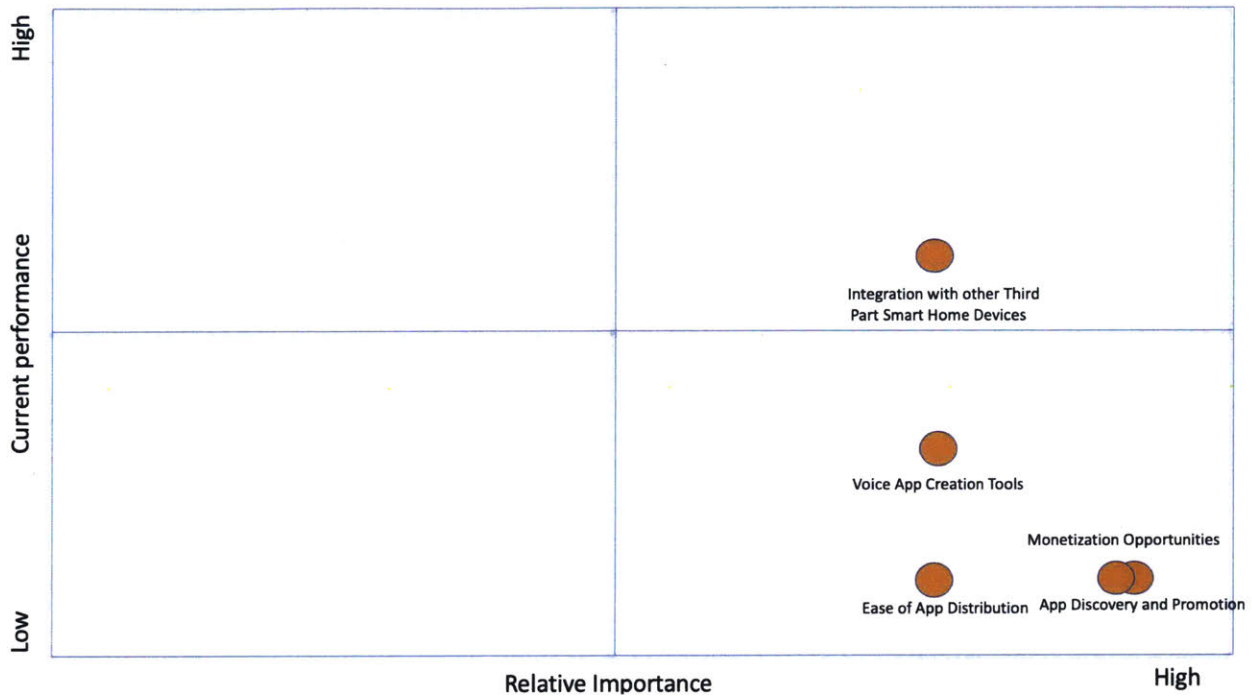


Figure 23 Microsoft Cortana Developers Stakeholder Value Map

Similar to its consumer strategy, Microsoft has decided to move away from supporting third-party developers for its consumer version of Cortana. If we look back to 2017, we can identify the key point in which Microsoft chose to pursue to abandon its consumer digital assistant strategy.

In April of 2017, Microsoft announced that a new type of digital assistant collaboration, the first of its kind, was revealed between Cortana and Amazon's Alexa (Shuman, 2017). Effectively, Cortana enabled devices and applications could now summon Alexa and vice versa. This was an interesting development in the battle for digital assistant dominance and it seemed that Microsoft had ceded the business to consumer (B2C) market since Alexa already held a significant market share lead. Many in the industry have already predicted that consumer digital assistant market would get crowded very soon and unfortunately, Microsoft did not have the mobile device installed base that other major vendors, such as Apple and Google, already had. Furthermore, to penetrate the smart speaker market would mean competing directly in an already crowded home market with the likes of Amazon and Google. As seen in the graphic below its share was

predicted to continue to fall in installed base and it would need massive resources just to compete in an already crowded and highly competitive market.

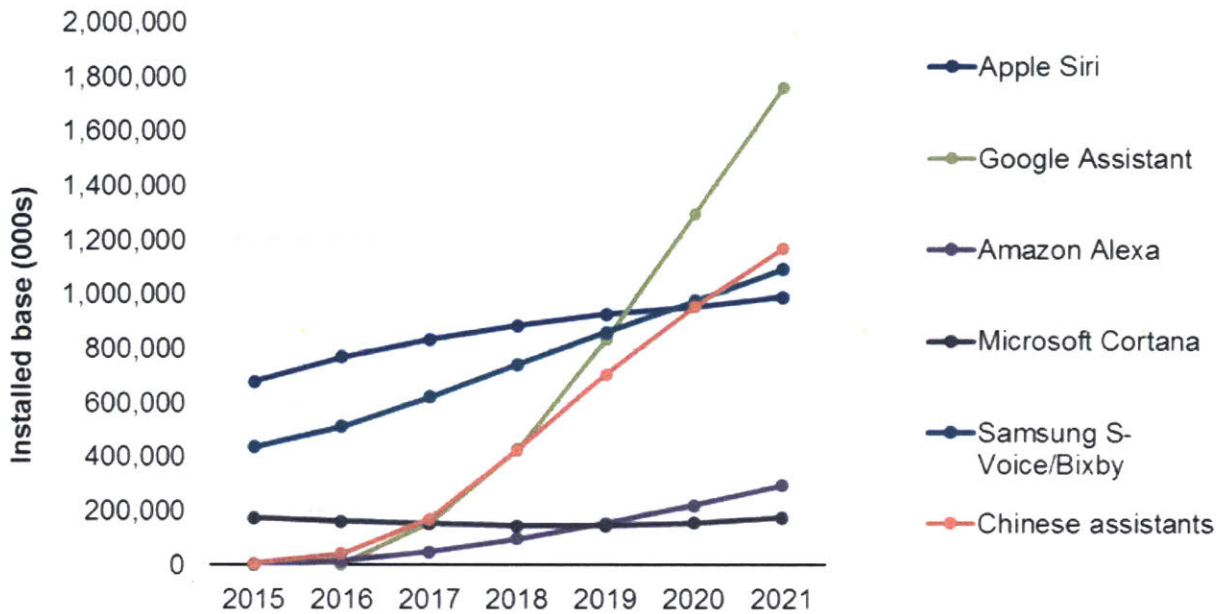


Figure 24 Install Base by Vendor (Ovum)

Microsoft likely saw this trend and decided to abandon its B2C strategy with Cortana; this is evident in recent events at CES where Cortana was nowhere to be seen (this was the *consumer* electronics show after all). Most telling however, is that Microsoft CEO Satya Nadella said himself that he no longer views Cortana as a competitor to Alexa or Assistant and instead views Cortana as a stand-alone app or skill that integrates with the other digital assistant platforms where every Microsoft 365 subscriber could invoke Cortana through their digital assistant of choice whether that is Google Assistant or Alexa (Warren, 2019). Google also no longer lists Microsoft as a competitor in the digital assistant space in its latest investor 10-K filing (Alphabet, 2019). It's clear that Cortana has left the consumer voice assistant war.

This seems to be a wise strategy by Microsoft as its core business competency now lies in the enterprise and not the consumer. Its latest resurgence is due in large part to its focus on B2B solutions such as enterprise cloud computing with their Azure offerings. Thus, while Cortana was once seen as a major competitor backed by Microsoft, with immense research and development resources, it is clear that its strategy has shifted away from B2C. Instead, Google Assistant and Alexa are now potential partners for Cortana and it has shifted resources to pursue this strategic

path (Foley, 2018). It is staking the success of its digital assistant as a complement to other assistant platforms and it has shifted focus to the B2B enterprise space, instead focusing on having Cortana as a portal to its Microsoft enterprise productivity tools.

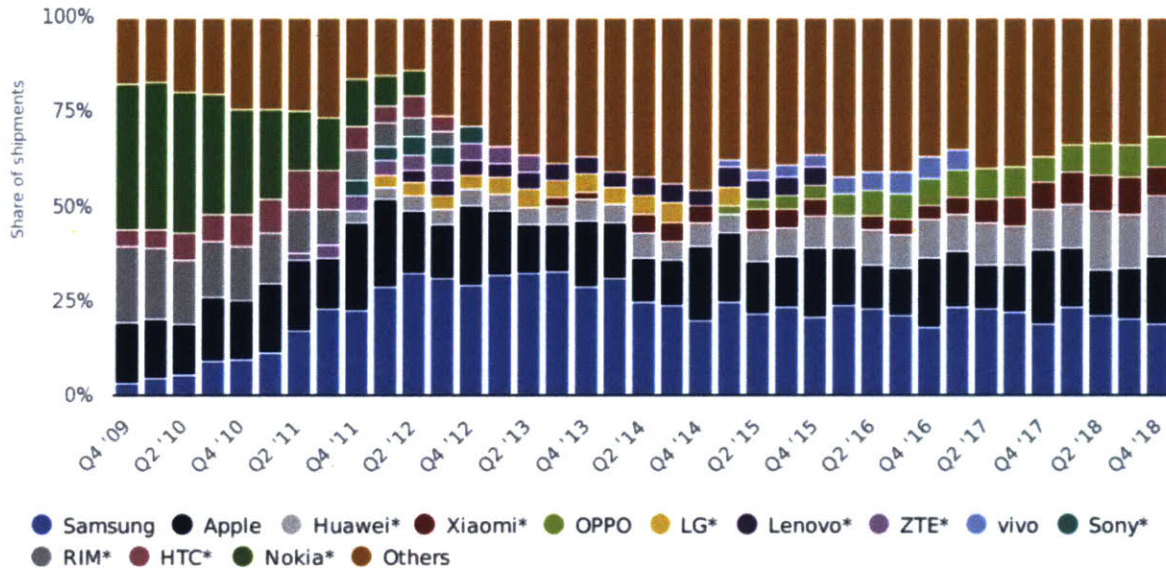
Samsung

Samsung pursues a core strategy wherein it leverages its vertically integrated capabilities to produce and sell consumer electronics. Samsung is a competitor with Apple, especially in the mobile smartphone space with the Galaxy line of devices. It is also a key partner with Apple, as one of its largest suppliers.

The Samsung Galaxy smartphones are direct competitors to Apple iPhone product in the premium smartphone segment. Samsung's digital assistant known as Bixby debuted in 2017 along with its flagship Galaxy smartphones. Bixby is loaded on Samsung devices including smartphones and tablet devices and performs in much the same way as the other major smartphone digital assistants. In fact, on many Android powered devices, Bixby was installed along with Google Assistant. While Bixby remains relatively new to Samsung, it was developed as a reboot from the original S Voice personal assistant app from Samsung. Most recently, Bixby 2.0 was announced with a vastly expanded vision of what Samsung's digital assistant could be.

While Bixby usage still remains low on smartphones, at only 6.23% (Wagner, 2018), with only Cortana being lower, Samsung has a unique positioning with a large market share of the smartphone device market. As seen in this figure, Samsung currently commands 18.7% of the global market share for smartphones and its Galaxy line of smartphones remains its core profit driver. Clearly, even if Bixby may be behind, Samsung is still a formidable player in the smartphone and consumer electronics space.

Global market share held by leading smartphone vendors from 4th quarter 2009 to 4th quarter 2018



Source
IDC
© Statista 2019

Additional Information:
Worldwide: IDC: 4th quarter 2009 to 4th quarter 2018



Figure 25 Global Smartphone Market Share

For Bixby, despite being a late entrant with its improved Bixby 2.0 product, we can see that many of its key stakeholders are still underserved.

Stakeholder Group: Consumers		
Samsung Bixby		
Value	How important is this value to stakeholder group (1 = low, 5 = high)	How well is enterprise delivering this value (1 = low, 5 = high)
Ease of Assistant Access	4	3
Accomplish First Party Tasks	3	2
Integrate with Third Party Apps	4	4
Privacy and Trust	4	2
Integrate with Core Samsung Competencies (e.g. other Samsung devices)	5	4

Table 9 Samsung Bixby Consumers Stakeholder Values

Samsung Bixby Consumers

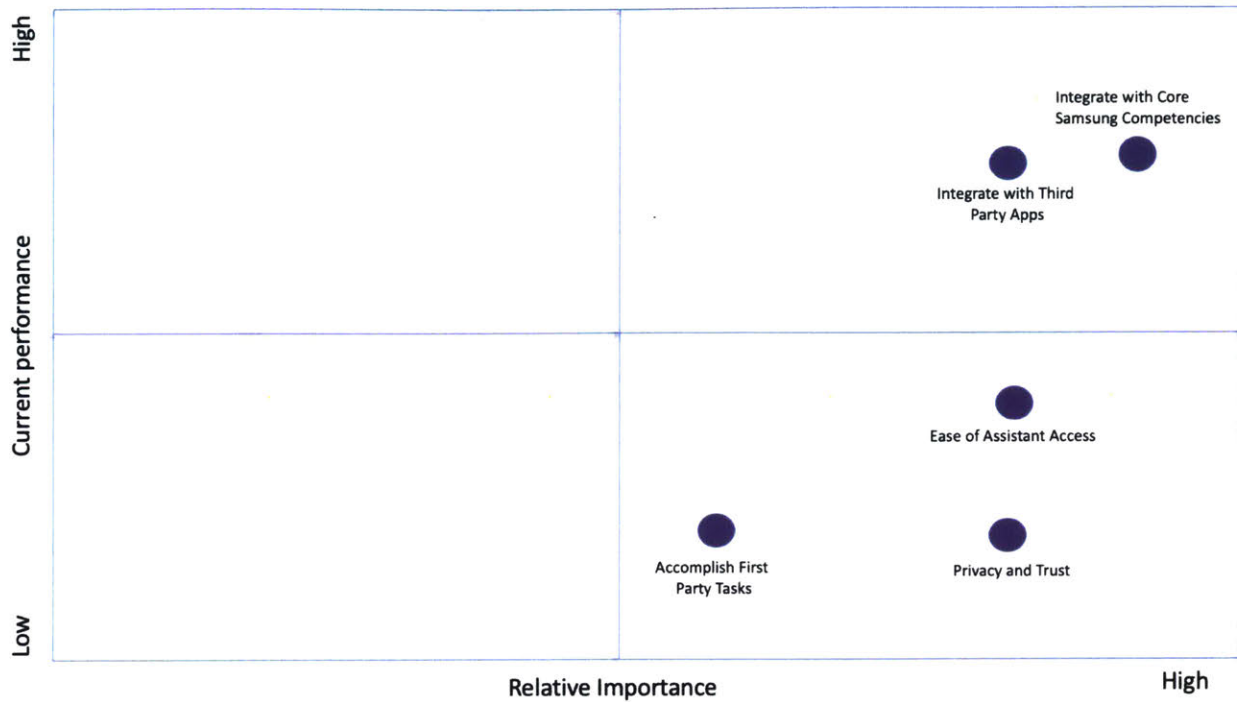


Figure 26 Samsung Bixby Consumers Stakeholder Value Map

Since Samsung does not have its own operating system, relying instead on Android, its Bixby assistant has to compete with Google Assistant on its line of Samsung Galaxy smartphone devices. This will remain a big challenge as Bixby continues to scale up, but we already see that Bixby has built a number of capabilities as it leverages its deep expertise in not just smartphone devices, but smart electronics and appliances across its entire portfolio of products. Indeed, we can see that Bixby already is deeply integrated with numerous smart home devices.

Stakeholder Group: Developers		
Samsung Bixby		
Value	How important is this value to stakeholder group (1 = low, 5= high)	How well is enterprise delivering this value (1 = low, 5= high)
Voice App Creation Tools	4	4
Ease of App Distribution	4	3
Monetization Opportunities	5	1
Integration with other Third Party Smart Home Devices	5	4
App Discovery and Promotion	5	2

Table 10 Samsung Bixby Developers Stakeholder Values

Samsung Bixby Developers

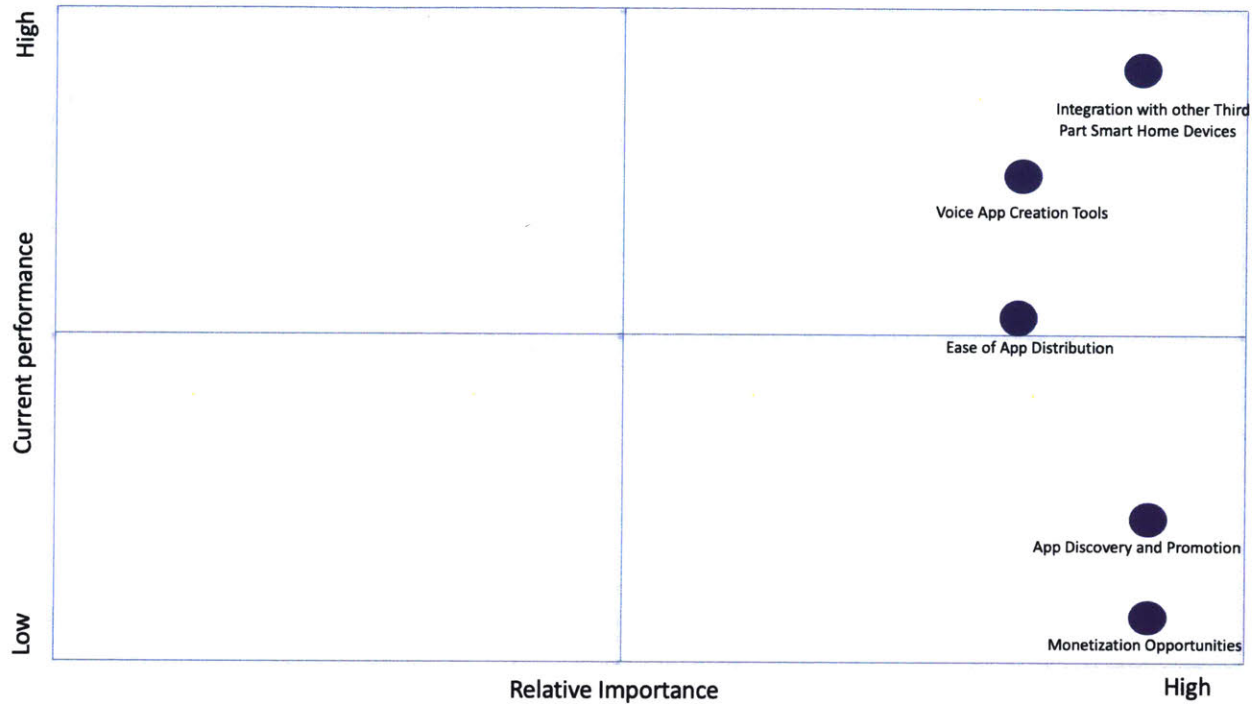


Figure 27 Samsung Bixby Developers Stakeholder Value Map

Similar to Assistant and Alexa, with Bixby Samsung seems to be pursuing a similar strategy allowing an open platform for third party developers. As the latest entrant to allow third party app development for its Assistant, it lags behind its competitors in terms of app distribution and facilitating voice app creation. Nonetheless, Bixby also faces the same challenges in app discovery and monetization for its developers. It remains to be seen if developers are interested in creating voice apps for distribution for three different assistants.

Furthermore, Samsung’s strategy has now shifted to encompass more than just Bixby on smartphones. Samsung builds a wide array of home appliances and devices and their focus on internet connected devices dovetails nicely with their Bixby 2.0 strategy. In this manner, it is competing directly with Alexa in the smart home. In fact, it hopes to build Bixby as a platform, a “marketplace for intelligence” (Chung, 2017) and it is in a unique position where it also already produces many home appliances and devices onto which it can load Bixby; this is the distinct advantage of being a completely vertically integrated electronics company. Finally, in addition to releasing the Galaxy Home device (a similar device to the Amazon Echo and Google Home)

Samsung is also now allowing third-party developers now to develop apps for Bixby (Kharpal, 2018) with a new SDK and API for Bixby.

While Samsung's current Bixby market share is low, it cannot be ignored as it has deep capabilities within home appliances and hardware and it has the ability to vertically integrate Bixby into its products with many decades of consumer electronics experience. This is especially true in the home media entertainment sector such as Samsung Smart HDTVs and kitchen appliances such as its smart refrigerator, the Family Hub. Having deep expertise and the ability to vertically integrate Bixby into these home products are unique advantages that other players such as Google, Amazon, or Apple have little to no experience in. The big challenges for Samsung remain whether Bixby can compete in AI capabilities. It's clear however, that Samsung is just getting started in the battle for the home against the other big three and by no means can it be counted out yet.

Others

The aforementioned digital assistants remain the major players in the digital assistant market but hardware makers in this space must also be mentioned even if they may not be developing their own digital assistant. The main players include the likes of Sonos, a California-based consumer electronics company that develops smart speakers, Ecobee, a Canadian firm focused on smart thermostats, and Philips, a massive Dutch multinational corporation that produces smart home appliances such as the Hue smart LED lamp systems. Amongst each of these home segments, include a wide array of other major device makers eager to enter the smart, IoT connected home market.

One thing that remains consistent amongst all these device makers is that they attempt to integrate with as many digital assistants as possible. For example, the Sonos One smart speaker is powered by Amazon's Alexa assistant with plans to also integrate with Google Assistant. Many other vendors allow integration with multiple digital assistant. These smart home device makers understand that smart devices and their usage with digital assistants will rise as seen in this graphic which predicts over eight billion user-digital assistant pairs by 2023, up from an estimated 3.25 billion currently.

Voice Assistants in Use

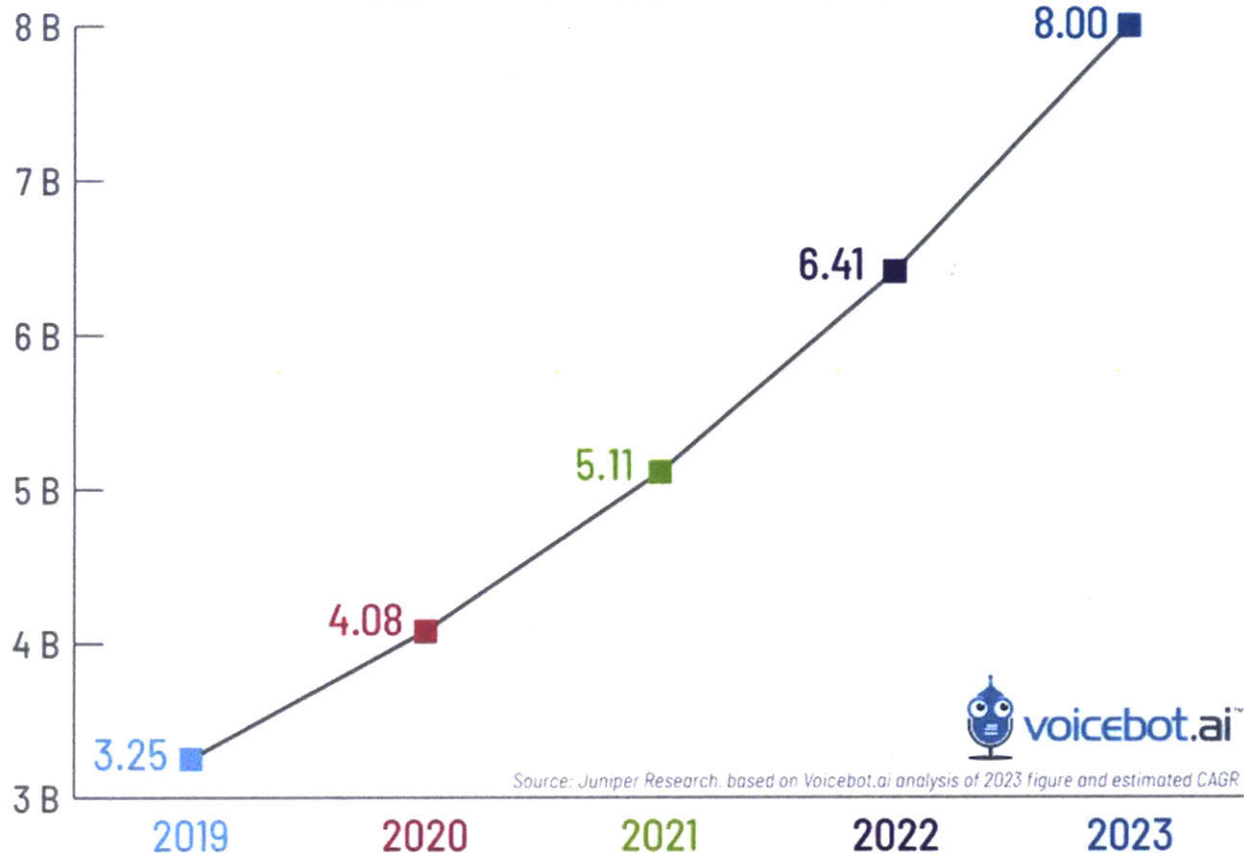
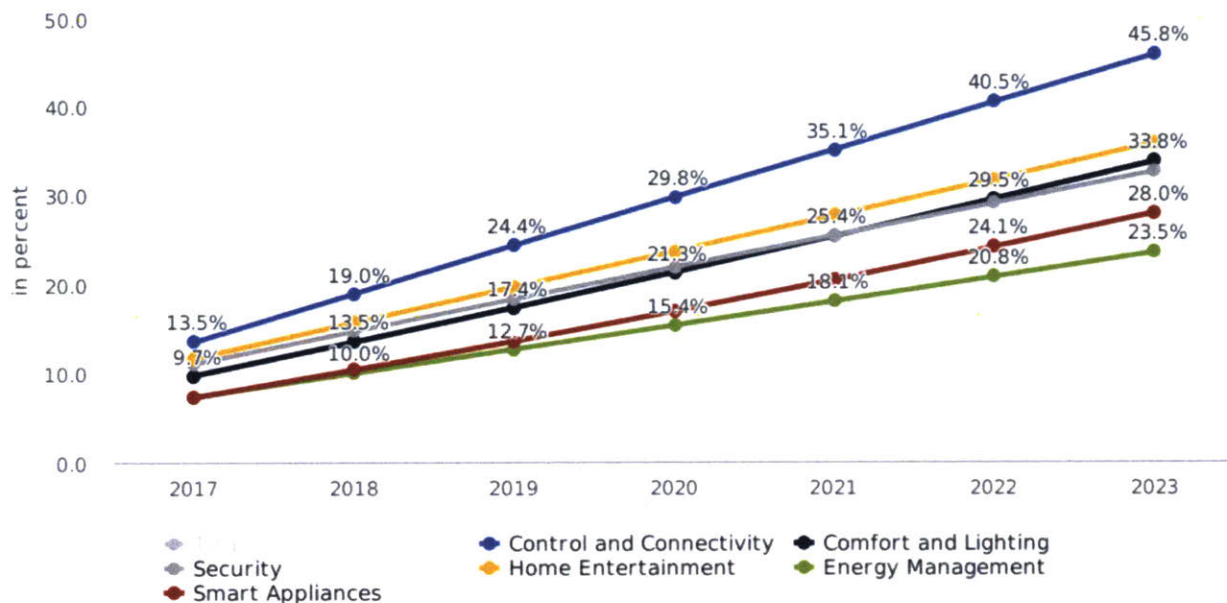


Figure 28 Voice Assistant Growth

While there may be only a few dominant voice assistants in use in the smart home, IoT device makers understand that they will need to be able to integrate with any of these digital assistants and are keeping their options open. Indeed, we see many smart home device makers touting their Assistant and Alexa integration. This remains a wait-and-see strategy by these device makers but they must be careful not to become commoditized hardware makers since each of the major forces in the digital assistant market also have plans to or are already releasing hardware devices of their own. Third-party integration is often not as smooth as native integration from the digital assistant makers so third-party device makers need to be cognizant and understand what specific, unique value they can bring with their offerings. There remains much opportunity in the smart home and Amazon, Google, Apple, Samsung may not be able to provide every smart device solution in the home. The highest areas of growth are seen below in the following figure.

Penetration Rate in the Smart Home market in percent (United States)



Source: Statista, November 2018

statista

Figure 29 Penetration Rate in Smart Home

The smart home device makers would be wise to continue concentrating on their core competencies while ensuring open integration with the major digital assistants. They do need to be careful and understand how their product is positioned against native offerings from the likes of Google and Amazon. As we see hardware prices fall driven by the commoditization of hardware electronics components, these third-party smart home device makers must ensure they too do not become commoditized and swallowed up by the tech giants.

Discussion, Implications, and Opportunities

Selection and Diffusion of Digital Assistants

From our analysis of the major players in the digital assistant market for the smart home, we can draw some important conclusions based on the current industry trends. This section will focus on predicting how the digital assistant industry may evolve based on each major player's overall company strategy as well as their current digital assistant strategies.

The first conclusion that can be drawn is that similar to the operating system platform wars in the early 1990s, the browser platform wars in the 2000s, and the mobile platform wars in the past decade, digital voice assistants will be another platform war and this may be the most profound one yet representing another tectonic shift in personal computing.

A platform war occurs when platform providers, such as Apple or Google, engage in a competition to build a technology platform to attract users on multiple sides of the market. With multi-sided markets, these platform companies compete not just on product and price, but also on the strength of both direct and indirect network externalities on each side to bring together even more buyers and sellers (Michael Cusumano, 2008). In the context of digital assistant voice platforms, these might be the number of third-party developers developing apps for Alexa or simply, the number of users interacting with their digital assistant. Both of these externalities drive positive feedback dynamics within the platform, increasing both the quality and stickiness of the platform and its complementary products.

Digital voice assistant companies are investing a tremendous amount into their voice platforms and it is clear that digital assistants are a key part of their strategy going forward. On a macro level, digital voice assistants will operate as a connective tissue in today's systems of systems and a successful digital assistant strategy will rest on its ability to be a platform for human computer interaction. Starting with a successful platform strategy is necessary to enable all the complementary tasks and activities people would need to accomplish in their smart home. With the number of smart devices expected to grow from 640 million devices as of 2018 to well over 1.3 billion devices by 2022 (Wright, 2018), the tasks performed in the smart home will become increasingly varied and diverse that it will require a unifying platform and an associated ecosystem to connect users and manage tasks within the smart home.

We see this as a clear trend wherein every major digital assistant provider is building not just a smart speaker with a digital assistant, but they are using the smart speaker as a conduit to expand their digital assistant's reach and ability to capture valuable user behavior and voice data. Major players are accomplishing this through voice SDKs such as Alexa skills, Google Assistant Actions, and even Siri Shortcuts and Apple HomeKit. Central to the success of any of these

digital assistants will be their ability to build a compelling, extensible voice platform to attract other developers. As evidenced by the operating systems wars, and the mobile app store wars, a healthy digital voice assistant ecosystem can be a major driving force to success. The question then is not whether or not a platform is needed for voice (to be clear, it is absolutely needed to enable an ecosystem of useful home voice applications) but rather what should be the defining characteristics of each major players' voice platform?

The second major conclusion that can be drawn is that companies need to decide on how open or closed will their platform be and what should the incentives be for developers and users alike of the digital voice ecosystem that they would like to build? Drawing upon the previous discussions on the open versus closed platforming strategies employed by Amazon and Apple, all key players must now decide if they should pursue an open or closed strategy for voice platforms? Or perhaps should it be open *and* closed at the same time? How extensible should the voice platform be? How much control or influence should the digital assistant company have over the entire ecosystem?

Amazon and to a lesser extent Samsung seem to be moving towards an entirely open platforming strategy. They are aiming to create a platform with the largest and most diverse third-party development community and going to great lengths to nurture this community through developer tools, SDKs, and community-building. Following a similar playbook to mobile app development may work but it is important to note that voice is fundamentally a different means of human computer interaction compared to text-based interaction in terms of app discovery and functionality. Most users care about getting things done - when they have a task, they just want it accomplished without regard to necessarily what assistant or app is being used. In fact, voice represents a one-shot chance at accomplishing the user's intent and the average user has little to no patience to set up third-party voice applications let alone trying to find the right one in the vast array of 50,000+ Amazon skills that are currently available.

Google, leveraging its own massive suite of products and services, has deep expertise in machine learning technologies and understands what it means to build a platform to support an ecosystem of complementary products. Its Android mobile operating system dominates the smartphone

market and their overall company strategy rests on being able to integrate their services and products into a coherent, personalized profile to meet the needs of its users. Google with Google Assistant is thus approaching the digital voice market in the home in a less open manner than Amazon is with Alexa (there are only a few thousand Google Actions) but instead, with its vast resources and deep expertise in AI technologies push forward to improve the core Assistant functionality. Google's strategy remains building the "smartest" and most personal digital assistant possible for its users, weaving together capabilities across all Google products and services.

Apple is approaching this war in line with how Apple typically operates – it lets others expend vast resources and time to experiment, all the while focusing on what Apple believes to be the best version of its own product. In line with its vertically integrated ecosystem strategy, Apple would like to ensure that Siri on native Apple products bring a superior customer experience on Apple products. This means Siri has deep integration with products like HomePod, Apple TV, and the iMac. That's not to say Siri cannot be used on other hardware devices since users can integrate Siri using the Shortcuts and HomeKit applications. The experience, however, remains noticeably inferior. Thus, Apple's third-party voice platform strategy can be characterized as closed but still open for developers with limited functionality and a lot of Apple oversight. The challenge for Apple remains whether or not it will be able to innovate quickly enough with Siri and provide a seamless enough experience across all devices to meet consumer needs in the smart home. Having complete control of your digital assistant on your own devices may allow greater flexibility and superior user experiences but if users can't accomplish tasks that they want to in the home, they may leave Siri for another assistant, starting a slippery slope where they may defect not just from Siri, but from other product platforms within the Apple ecosystem. This is Apple's worst nightmare.

Finally, while the media may paint this as a war that has already been decided, it is actually still extremely early and we are still in the experimental stage in these voice wars. The true winner or winners in this platform war remain to be seen. As evidenced by the "Alexa everywhere" strategy, many companies are still experimenting and have not found how to monetize much less define what constitutes success in this market. While digital assistants have been around since

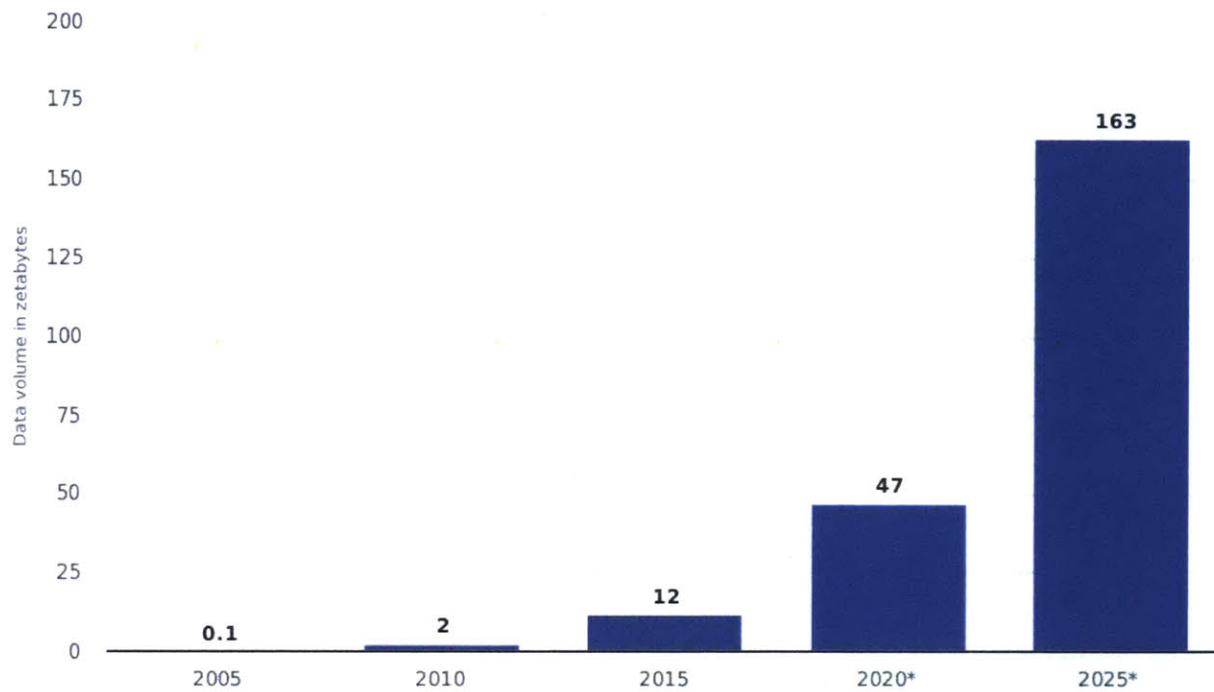
the 1950s, the recent explosion of digital assistants into the consumer mainstream has only occurred in the past couple of years. Much like the mobile platform wars that led to the tremendous success of companies like Facebook and Uber, the voice assistant platform wars may still reveal other players that are able to take advantage and rise to the top over the current tech giant incumbents. The war has just begun.

The Smart Home in 2030

To understand where digital assistants may be headed, this section will make a series of informed predictions on what the smart home will look like over the next decade, in the year 2030. More importantly, this section attempts to extrapolate, based on what the 2030 smart home looks like, what new consumer needs and activities may be present and what current digital assistants should be building towards. Ten years is a long time in the world of technology but this is not simply some piece of new technology that drops into consumers' homes, digital voice assistants will fundamentally reshape how people live.

The first prediction is that many more things will have sensors and be able to collect data. From obvious appliances such as stoves, security cameras, and light switches, to less obvious home furniture such as toilets, chairs, and even your bed, more and more things will have data collected about itself. The figure below shows the explosive growth of data since 2005 and the projected data volume in 2025.

Volume of data/information created worldwide from 2005 to 2025 (in zetabytes)



Sources

IDC, Kleiner Perkins Caufield & Byers; Seagate
© Statista 2018

Additional Information:

Worldwide; IDC; 2005 to 2017

statista

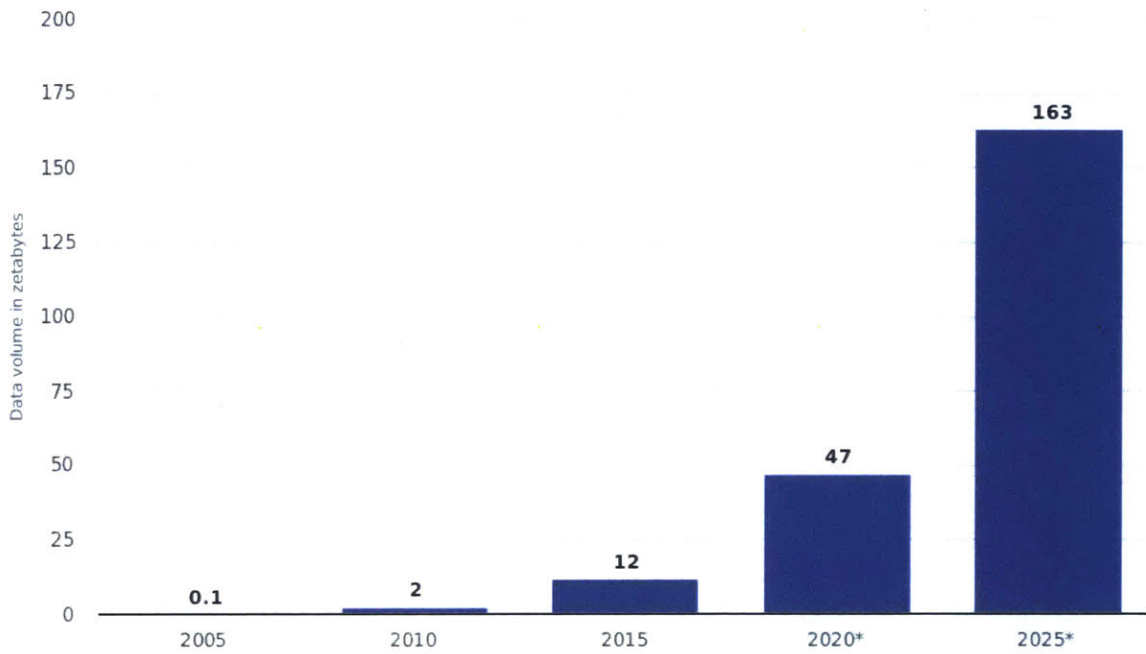
Figure 30 Volume of Worldwide Data

Furniture will have embedded sensors in order to collect data about itself including its current status, how long it has been in use, how many times it has been used, and many other data points. Even your toilet will be able to track how often you use it and how much water you're using over the course of days and weeks. Your bed will be connected and collect data about how long you are sleeping, the quality of your sleep, and make all the data available for consumers. Your refrigerator will be smarter than ever, collecting data about what types of foods are stored, how long they have been sitting in the refrigerator, and even the lifetime of the produce. Indeed, smart refrigerators are already being produced by Samsung (Samsung, n.d.) The smart home will be first and foremost a data collection point for nearly every imaginable piece of home furniture or appliance. All this data, will then be fed to a central repository where it can be aggregated and analyzed to inform what the best course of action is for the consumer. Furthermore, data across homes can be collected and analyzed at even a greater scale to improve energy efficiency, and

used to inform predictive maintenance technologies. Obviously, there are a number of data privacy issues present here but for now, this analysis will focus on making the 2030 smart home fully able to aggregate all data.

The next prediction is that tasks will be increasingly performed by context-aware robots as home appliances and furniture becomes better integrated. Robots in the home may seem like scary science fiction, but I believe that robots will be increasingly accepted in the home. While there are robots in the form of self-cleaning vacuums such as the Roomba, the home robots in 2030 will be much more sophisticated. Powered by vastly more sophisticated AI and machine learning algorithms, robots will be able to help perform tasks such as moving furniture or gardening tasks. The dexterity of these robots will drastically improve to the point where many tasks will be much better suited for robots to perform. This also includes the class of robotics related to drones as they are able to assist with many home tasks. We already see robotics taking hold in industrial settings as their growth, fueled by better AI software has led to exponential growth in recent times.

Volume of data/information created worldwide from 2005 to 2025 (in zetabytes)



Sources

IDC; Kleiner Perkins Caufield & Byers; Seagate
© Statista 2018

Additional Information:

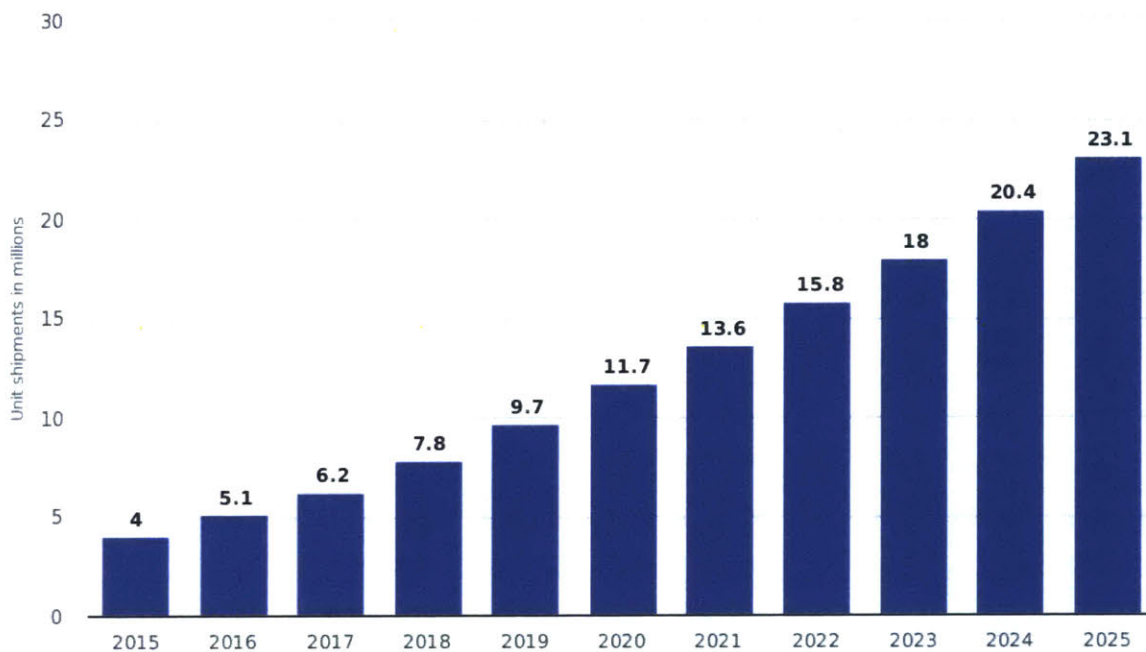
Worldwide; IDC: 2005 to 2017

statista

Figure 31 Sales of Industrial Robots

As robots become more useful in industrial settings, they will naturally diffuse into consumer settings in the smart home. Users already use many tools in the home (e.g. lawnmower, vacuum, garbage cans); unfortunately, they just aren't smart enough yet. The projected growth of domestic robots are as follows:

Unit shipments of domestic consumer robots worldwide from 2015 to 2025 (in millions)*



Source
Loup Ventures
© Statista 2018

Additional Information:
Worldwide; Loup Ventures; 2015 to 2016

statista

Figure 32 Shipments of Domestic Robots

Finally, the last prediction which is also closely related to the first, is that every part of the smart home will become functional and context-aware to serve multiple needs. What this means is that a wall is no longer simply a wall – it might be a touch-enabled display that can display information about the weather, in another instance, it might restart a halfway-through Disney movie for the kids, and on a bright sunny morning, it might switch from opaque to translucent precisely as the time that a user wakes up. As the human population explodes over the next decade and land becomes even more scarce, we will completely reimagine what the home looks like. In fact, shared home spaces have become an important trend as millennials find it harder and harder to purchase a home. In this concept, traditional parts of the home are shared for communal activities such as eating or cooking in the kitchen (Raval, 2018). This will then require every piece of furniture, every door or window to be able to remember and adapt to different users in various contexts.

The way each of these predictions will come to fruition requires some kind of “connective tissue” that can coordinate data gathering, stateful awareness of the context within the home, and responding accordingly. A human cannot possibly keep track of, let alone process everything that is going on in her smart home. This is where digital voice assistants will shine since they will have a holistic view of what is going in the house, what has happened in the past, and respond perfectly to what the future. A stateful, context aware digital assistant will need to be able to coordinate all these tasks in the smart home and its clear, digital voice assistants will be a key enabler for the smart home of 2030.

How Digital Voice Assistant Companies Can Create Value

The previous section paints a very futuristic home but with how fast technology changes and how profoundly life-changing AI technologies can be, I believe that the smart home in 2030 will be nearly unrecognizable compared to the homes of today. Now that we understand what that smart home might look like, the purpose of this section is to elucidate how digital voice assistant firms can create value for consumers in the smart home of 2030.

The first way is that digital voice assistants must be built as a platform to enable complementors and third-party developers to integrate different functions in the home. As mentioned previously, because of the variety of use cases and needs in the smart home, no one company can possibly meet every need in the consumer home since there are simply too many use cases. This presents an extremely exciting opportunity for firms to come in and build a voice platform for the smart home. This platform must be extensible, secure, and easy to develop on for third-party application developers. It must also be able to easily connect with other devices and services.

More specifically, the digital voice assistant must be a platform that does not have stringent hardware requirements and instead should be as flexible as possible for hardware device manufacturers. Consumer electronics hardware is now much cheaper and much more easily accessible. The barriers to entry to procure consumer electronics for hardware manufacturers is also much lower than in the past with the availability of global, distributed supply chains. One of the early blunders by Apple was requiring hardware manufacturers to use a specific Apple-

approved security chip in order for the smart device to work properly with HomeKit (Fingas, 2017). In fact, Apple even required some HomeKit compatible devices to be manufactured at specific Apple designated manufacturing facilities. While the intention may have been good, since Apple wanted to ensure hardware device manufacturers were following privacy and build quality standards set by Apple, the requirements for a special chip made it too onerous for hardware manufacturers and they instead simply decided not to build hardware specifically for HomeKit compatibility. Since the proliferation of Alexa and Assistant enabled devices, Apple has since relaxed their policies around requiring HomeKit compatible devices to have specialized hardware.

The second important key to creating value in this market is that firms must focus on building assistants that provide more value than traditional touch-based interactive devices. Consumers are incredibly adept and fully comfortable with how to use their smartphone and tablet devices to accomplish tasks. While typing on a tiny five-inch screen is less intuitive and natural than speaking commands out, since the rise of the smartphone in the past ten years, screen-based task interactions have become fully normalized. Thus, in order for voice assistants to provide increased value to consumers, it needs to be at parity with screen-based tasks. In fact, a step towards the future may be one-shot answers - where the assistant provides a single omniscient answer to create the most value for users similar to how Google search operates today. Users may not want to expend mental energy in figuring out which of the ten possible answers are correct. There are a class of queries based on empirical knowledge that only have one answer and digital assistants should be able to return that same answer every time. For example, a question about Barack Obama as a president of the U.S. will always and forever be true – there is no need to ever have more than one answer for the query “Who was the 44th president of the United States”. Likewise, the query “Is the Earth round?” will always have one correct answer. Digital voice assistants, because they are a fundamentally different interaction modality often times can only give one answer through voice, and thus, must ensure they return the correct answer for users on simple one-shot queries.

In creating more value than currently available through screen based personal computing, voice has a unique advantage in integrating with other smart home devices since many makers are now building voice enablement into their products bringing even more utility to users.

The prediction here is that there isn't going to be one killer application, rather, voice is going to be another modality to achieve those same use cases. There will certainly be new applications that spring up leveraging voice as a new modality of human computer interaction but the key to voice adoption is to focus on accomplishing the current set of tasks consistently better than utilizing traditional screen-based interactions. This was true starting with the initial adoption of smartphones (texting, email, phone calling were the first big uses cases that drove adoption) and I believe that to be the case here with voice as well. The average consumer is inherently inclined to default to behaviors with which they are familiar and comfortable with. Digital voice assistants must demonstrate real increased value to persuade users to switch from what they are used to and eventually build new habits around accomplishing tasks through voice.

As consumers build trust in what their digital voice assistants can accomplish and they see real value in utilizing voice rather than traditional screen-based interactions, both the variety and volume of digital voice assistant usage will increase and new consumer habits will be formed. The challenge is if firms can build digital voice assistants that are competent enough to provide a big enough value proposition for users to switch over.

Finally, and perhaps most importantly, companies must focus on critical consumer needs in first party services and ensure their digital assistant is robust enough to be able to perform in nearly every conceivable circumstance to meet those needs. It must be reliable on simple tasks such as checking the weather and setting timers before moving on to more complex tasks. This requires more robust speech recognition and better natural language understanding across many dimensions including user phrasing, accents, different speakers in various settings, and context awareness. Digital voice assistants should truly act as a real assistant, not an "if this then that" (IFTT) scripting bot. As more users gain confidence in their digital assistant, frequency and variety of usage will increase and deeper assistant interactions will follow. This will foster a better user-developer app ecosystem and the network effects will quickly help the widespread

adoption of digital voice assistants. Building this trust takes time and it begins with the companies understanding that they must start small and gradually build up.

How Digital Voice Assistant Companies Can Capture Value

In order for companies to capture the value that is created, first, they must prioritize user trust and be abundantly clear what their digital assistant's data policy is with respect to the privacy of their users. Firms cannot be disingenuous and take advantage of consumer ignorance in regards to their data and privacy. As we've seen with the fallout from the Facebook data privacy scandals, trust takes years to build up but can be irreparably broken in an instant. Companies also need to provide tools for users to manage and understand what is happening with regards to their data while using personal voice assistants. Perhaps some users are perfectly content to have every single purchase tracked if it means that Alexa could suggest a more personalized shopping experience for them. On the other hand, some users may find this intrusive and would want to restrict or even retroactively redact their purchase information from their Alexa device. The key here is to give users a choice so that they feel like they are in control, all the while delivering more value to users as the assistant becomes smarter.

Tactically, companies should foster a voice ecosystem and incentivize third-party developers. As mentioned before, no one company can do it all and meet user needs in the home. A voice assistant platform wherein third-party hardware and software vendors are incentivized to come in and add value allows the creation of a robust ecosystem which is critical for a firm's digital assistant to have long-term success. Thus, companies must not only continue building up the capabilities of their digital voice assistant but also enable, and incentivize third party developers to build on their voice platform. This is already the trend we see from Amazon, Google, Samsung, and even Apple. Much like the Apple App Store and Google Play services for the mobile environment, there may only be room for a few digital voice assistant platforms as the switching costs to develop voice apps on multiple platforms may be too high since each platform will have different requirements. Firms can focus on incentivizing third-party developers to build apps on their platform through marketing, advertising, and providing voice application infrastructure that makes it easy to develop on. The Alexa platform can be considered the current leader with respect to third-party development since it has made it so easy that currently, there

are actually no requirements or checks for third-party developers to release an Alexa Skill into the marketplace (Crum, 2019). At the other end of the spectrum, Apple is much more restrictive in ensuring which applications can exist on its App Store and which can work with HomeKit. The key here is for companies to understand what strategies make sense for them given their strategic goals for their digital assistant platform.

Next, there must be a robust mechanism for firms to gather feedback in order to improve their digital assistants. Beyond just simply gathering queries and consumer data from digital assistant usage, they must allow third-party developers and users alike to provide feedback on the actions they are taking and the applications they are engaging along with the context in which these queries are being asked. Current retention is so low with some voice applications that they barely cross the 6% retention rate which is already a markedly improved rate from earlier in the year (Marchick, 2017) but still lagging behind mobile application retention rates significantly. These cases of one-and-done with voice applications means many apps remain unused and both digital assistant firms and third-party developers cannot get valuable feedback in order to improve. This negative feedback cycle can lead to a proliferation of worse quality voice applications within the ecosystem, meaning even less users, and less data to collect and train the AI assistant with. Indeed, while Amazon is quick to claim their dominance in the number of Alexa skills available (over 50,000 and increasing), most of them have no ratings and certainly no reviews as seen in the figure below.

Alexa Skill Ratings Total Breakdown

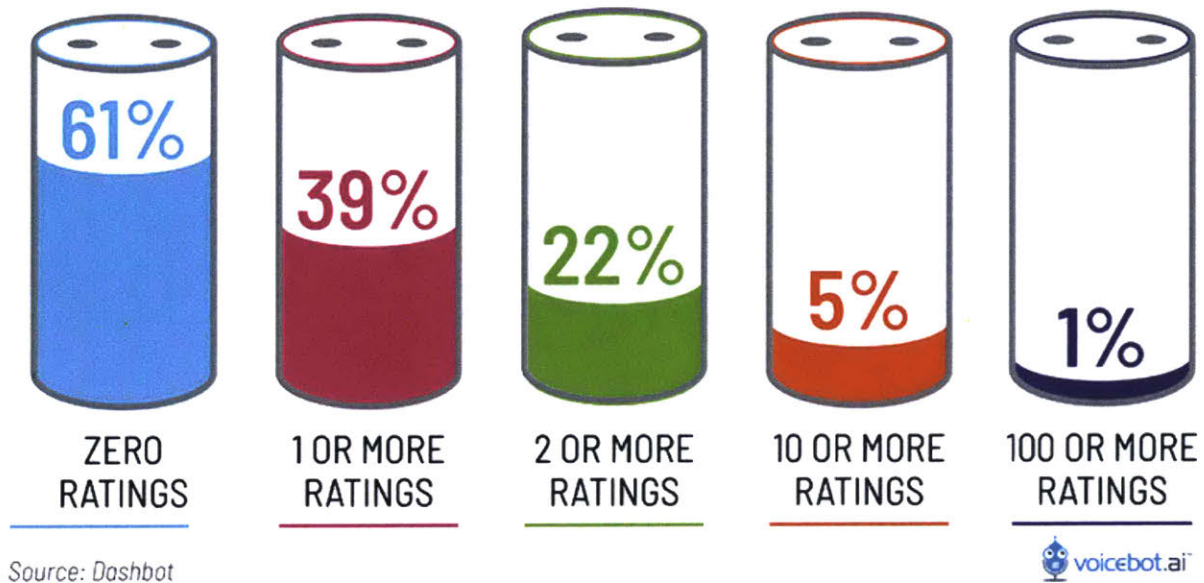


Figure 33 Alexa Skill Ratings

Digital assistant firms must find a way to engage users and third-party voice application developers alike and they must figure out how to incentivize users and developers to continue engaging with their voice assistant platform.

Another way in which major players can capture value revolves around promoting deeper digital assistant usage through increasing user awareness and habituation with their digital voice assistant. To test this hypothesis, a demographic study was performed with members of the MIT community on their digital assistant usage to measure their awareness and resulting levels of trust after sustained usage with a digital voice assistant. The study was performed as part of a study on human factors engineering (Kagami, Vemuptalli, Vetter, Ke, Wang, 2018). The methods and results are detailed as follows:

Survey Design

One single digital voice assistant (Apple Siri) on a device will receive voice input from the test subject. The subject will have a task to perform (e.g. find out the weather), and will be assessed on their performance and accuracy of results from the digital voice assistant. The subject will also

be timed on their ability to complete the task. In addition, a survey was executed to understand demographics of the test subject (found in appendix).

Digital Assistant System

In this experiment, Siri and an Apple iPhone 6S Plus with iOS 12.1, with the latest updates were used as the digital voice assistant system to perform this study. To keep Siri from adapting to the subject's voice during test cycles, the digital assistant was reset every time after a subject finished the survey.

Demographic Survey Design

The purpose of the initial demographics survey is understanding the demographics which might affect the ability of one's performance on a task utilizing a digital voice assistant (found in appendix).

We developed the following question areas in the demographic initial survey:

1. Sex
2. Age
3. First language
4. English accent (perceived)
5. Strength of one's accent (perceived)
6. Smartphone operating system(s) which is/are one feel most comfortable with
7. Proficiency with a smartphone
8. Digital assistant system one has used
9. Proficiency with virtual assistant system(s)
10. Current (before a survey) level of trust on the information in using a virtual assistant system(s)
11. Current (after a survey) level of trust on the information in using a virtual assistant system(s)

We hypothesize that the voice recognition is generally affected by sex (1), age (2), and subject's English accent (4) (possibly affected by subject's first language (3)). In addition, proficiency and experience in using smartphone (6,7) and any voice recognition system (8,9) may affect the test results in utilizing a digital voice assistant system. The reason for choosing a proficiency in using

smartphone metric is that the digital assistant system operates within the context of a smartphone device through voice activation.

For 1, 2, 3, 4, 6, and 8, the subject answers them with no limitation. On the other hand, we need to measure subject’s strength of English accent and proficiency in using smartphone or digital assistant systems in comparable way, thus we asked a subject to rate in five levels. The standards for each level in this survey is shown in the survey sheet (found in Appendix)

Furthermore, we asked one's trust level in a digital assistant system(s). This is based on our assumption that the results of the survey affect the one's trust on the system, thus we asked this question before and after the survey (10,11).

Task Design

The subjects were asked to perform ten basic tasks using Siri. The subject performed tasks such as “find out today’s weather.” Each task was listed on an individual note card, and the subject turned over the notecard to indicate the start time of that task. Subjects were rated based on the time required to perform a task, and the investigator rated the correctness of each response on a scale of 1 (incorrect), 2 (partial), and 3 (correct).

To evaluate the ability of Siri and a subject, tasks shown in the below table is set up. The tasks are combination of simple and complicated tasks, and in the order of simplicity. The simplicity of tasks here means that the number of condition (such as "latest", "public transportation", "contribution" etc.) in tasks. We also included tasks which Siri should manage other Apps existing on the test smartphone. The expected response from Siri is also described below.

	Task List	Expected response from Siri
1	Current location's weather	Search and reply with the weather in the testing location
	Set a 6:04 AM alarm	Set an alarm on 6:04 AM

2		
3	Latest Patriots game score	Search and reply with the results of latest Patriots game
4	Public transportation directions to Fenway Park	Search (by using Maps) and reply with the direction from the testing location to Fenway Park in using public transportation.
5	Add "grocery shopping" to to-do list	Add "grocery shopping" to to-do list
6	Turn off Bluetooth	Turn off Bluetooth
7	Find out the number 1 song on billboard chart	Search and reply with the number 1 song on the billboard chart
8	Find out what 1-meter equals to inches	Search and reply with the inches equivalent to 1 meter
9	Delete the alarm for tomorrow morning at 6:04 AM	Delete the alarm on 6:04 AM set in Q2
10	Find out Henry Ford's contribution	Search and reply with the contribution of Henry Ford

Subjects

Subject were recruited through direct email messages, phone calls or word of mouth. For recruiting subjects, the recruiting message in Appendix 6.3 was sent. Willing participants received relevant background information and consent forms prior to the beginning of their participation in the study.

We recruited 40 MIT students who are above 18 years old and 31 among them were actually were tested (nine potential subjects were not available for the survey because of scheduling conflicts). The subjects' demographics are shown in the Appendix.

Execution of the survey

The survey was executed at E40-315 in MIT and E17-361. The procedure and scripts used for executing the survey is shown in the Appendix. Only consented subject performed the survey. Figure 5 depicts the standard setup that was utilized for all subjects.

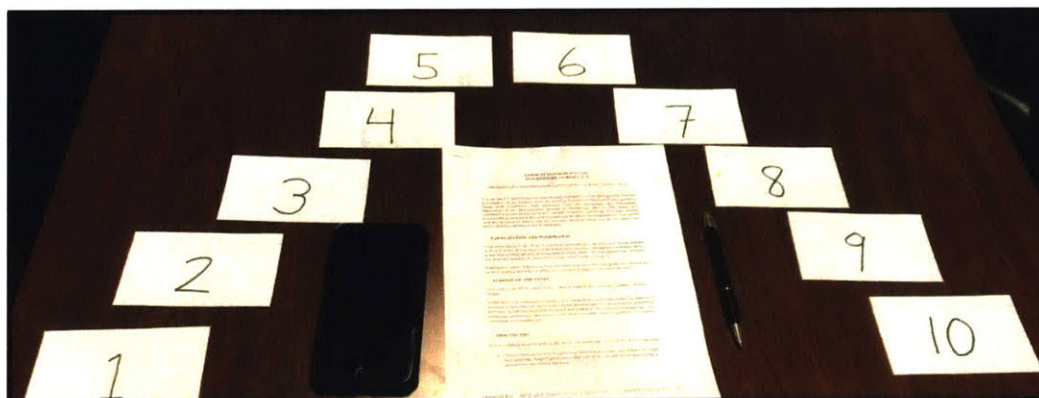


Figure 5: Standard Study Setup

Some observations made by the researchers during the tests were:

- During the tests, some subjects with strong accents were found to take multiple attempts to get Siri to understand them clearly.
- Most test subjects who gave incorrect commands to Siri or whose commands were incorporated incorrectly by Siri, were able to adapt by rephrasing the question when interacting with Siri to achieve the required outcome.
- After the tests, 20 out of 31 test subjects mentioned their increased confidence in Siri and that some would be interested in using the system in the future.

A key observation from this study is that no user had a decrease in trust for Siri after testing even when Siri provided less-than optimal answers. Moreover, 20 out of 31 users said they would trust the systems more after the ten-task question list. Many test subjects mentioned that they were surprised to find out that Siri was able to achieve some complex tasks that previously were unknown to them. This indicates that increased usage of Siri also increased user's trust with the system. Therefore, to promote the trust of Siri and other digital assistant systems among users, proper training and encouraging increased usages, along with improving the technical abilities of these systems need to be actively pursued by makers of digital assistant systems.

Based on these results, companies should engage in a strategy that increases awareness of a digital assistant's capabilities and that prioritizes user trust. This can be achieved first by ensuring their digital assistant is reliable and consistent on simple tasks first and foremost. Most consumers are hesitant to try complex queries with their digital assistant simply because a lack of trust that their assistant can perform adequately on simple tasks. Having your assistant order the wrong Thai dish from your local restaurant is an annoying inconvenience. Having it book the incorrect flight will likely lead to the user never using the digital assistant again. Therefore, firms must begin with perfecting their ability to address basic first-party tasks to allow for a consistent and reliable user experience. The assistant should not provide obviously incorrect answers. This is much harder than it seems to address but is critical in building up consumer trust of their digital assistant to perform on first-party tasks. Simple queries that have one single right answer should always be returned properly to users. Firms should focus on building up their capabilities to supply unambiguously correct one-shot answers on simple queries. The following is the latest benchmarks and while much improvement has been made, there remains a lot of work to do as even one incorrect answer for every ten queries is not good enough for users, especially in the command space.

Queries Answered Correctly by Category

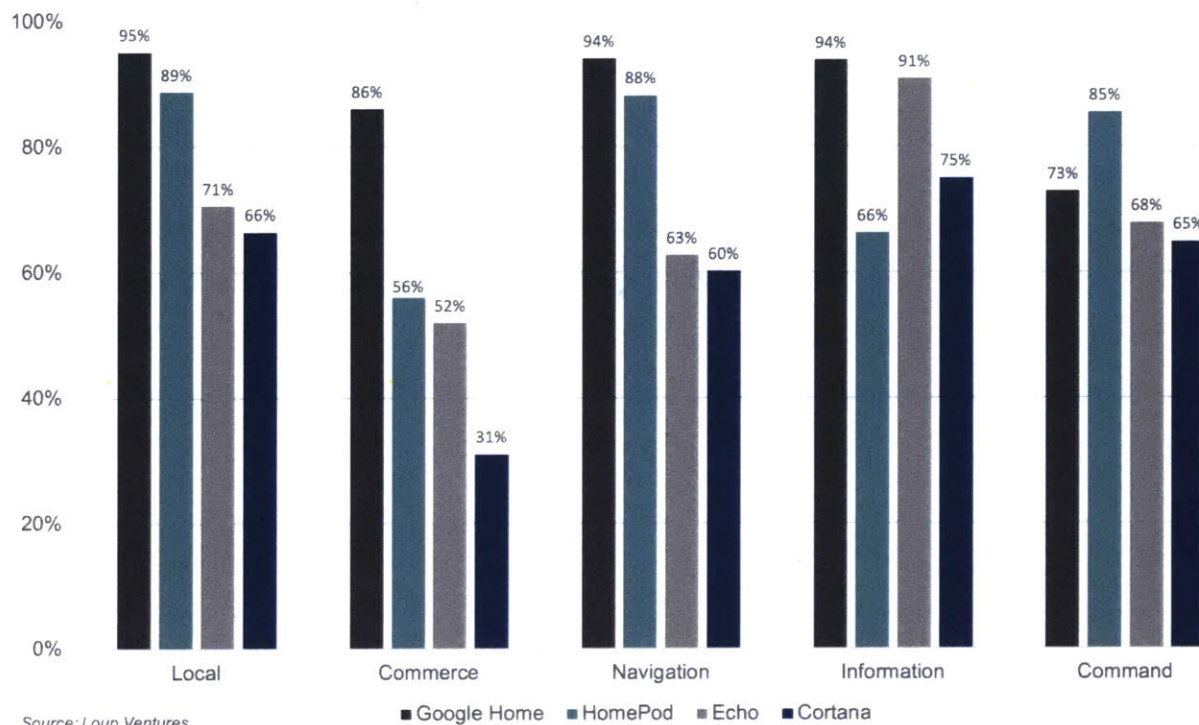


Figure 34 Queries Answered Correctly by Assistant

As digital assistants improve their capabilities first on simple first-party services and ensure high reliability, users will then become gradually habituated to perform more and more tasks with voice. As the volume of digital assistant usage increases, this will lead to even more data collected which improves the machine learning systems that power these assistants. Additionally, as users entrust their digital assistants to accomplish more and more tasks, they will begin to perform even more varied and complex tasks across a wide variety of domains. Further improvements in their digital assistants follows as even better user data is captured. This positive feedback loop is incredibly important for companies and is the key determinant in creating a sustainable competitive advantage.

The last way in which companies can capture value is to build a more natural, digital assistant that learns over time and becomes personalized to its user. This follows naturally from increased digital assistant usage as the assistant learns the context and history of its user to better inform future queries. Consumers are just beginning to become more comfortable with AI powered technologies and this transition can be eased by building a digital assistant that has the abilities

and personality akin to a real personal assistant. A digital voice assistant should speak like a human, with the same intonations and nuances of conversational human speech to allow users to develop a bond. It should also remember and learn user specific preferences and needs so that over time, the assistant becomes so in tune with its user so as to make itself truly indispensable to the user. It should be able to discern different users and remember the entire history of conversation with that user. Forging a deep emotional bond with the digital voice assistant may sound like something from a movie, but this is critical in establishing an emotional connection if the digital personal assistant is to ever become a central part of the consumer's life. The home is such a personal space that digital voice assistants should feel like a part of the family rather than a cold lifeless piece of voice technology.

To sum up, digital voice assistant firms that will capture value will be wise to focus on a few key points. First, they must nurture the voice ecosystem by properly incentivizing users and developers alike to drive increased awareness and usage to habituate both groups to building for and using their digital assistants. Second, they must be able to rapidly ingest and process data about users' voice actions and applications in order to continuously improve and build a context-aware, hyper-personalized digital assistant. The world is a dynamic changing place and digital assistants must be able to learn and become smarter every day to meet the needs of their specific user. Finally, and most importantly, a digital voice assistant firm's likelihood of success rests on their ability to foster and maintain user trust in their assistant. Trust, along many different dimensions, is the basis for large-scale habit-forming digital assistant usage which will be the key determinant in the adoption and sustained success for a company's personal digital assistants.

The Endgame

This section will analyze how this war ultimately plays out, specifically for the three major incumbents in the digital assistant space. More specifically, because many consumers already own a smart speaker or have readily available access to a voice assistant, I will analyze whether or not in the long run consumers will multi-home voice assistants and what are the conditions in which they might do so. Then, I'll talk about what success in the home might look like for the major players in the context of consumers having access to one or more digital assistants.

There are three important sub-questions to consider with respect to multi-homing:

- 1) Could the cognitive load for multi-homing or switching voice assistants be sufficiently high enough such that consumers would rather not switch and are instead willing to use a suboptimal assistant for specific tasks?
- 2) Will the capabilities of digital assistants converge across different use contexts such that the relative advantage that a particular assistant possesses in a specific context is not great enough to warrant multi-homing?
- 3) For consumers who may not be aware of the capabilities of their digital assistants or who are already habituated to a specific digital assistant, how might companies drive awareness of the capabilities and entice consumers to multi-home or even switch?

For both 1) and 2), my belief is that the answer is yes in most contexts. I'll address each of these questions from the viewpoint of each of the major digital assistant players.

In the context of digital home media (content streaming, smartphone usage, wearables in the home), Apple is by far the most dominant player, with Amazon a close second due to their extensive third-party integrations and digital streaming offerings. This is in large part due to Apple's strong device presence not just in the home, but in contexts outside of the home (car, smartphone, wearables, etc.). This presents a significant advantage in ensuring consumers do not multi-home and remain with Siri because they are habituated with Siri in so many contexts outside the home. Furthermore, the capabilities of Siri will continue to improve such that the relative advantage of other assistants will not be so great so as to entice Apple users to multi-home or switch. Apple is fast follower and will continue to slowly gain market share in this space as both the breadth of devices in the Apple ecosystem increases and as Siri improves.

Amazon is currently the leader right now in smart speaker install base due to aggressive pricing of their Echo hardware as well as leading in overall e-commerce. It is trying to extend this

market share advantage further by pursuing an "Alexa everywhere" strategy where it is also integrating with third-party device makers and allowing third-party app developers to easily develop with Alexa. If Alexa continues to further extend its reach in the consumer smart home (thermostats, appliances, media electronics, etc.), we could imagine a home where Alexa controls most of the devices (which are most likely purchased from Amazon.com). Thus, consumers come to rely on Alexa as it becomes the primary digital assistant for accomplishing tasks through third party apps and smart devices in their home.

This leaves Google and I believe that their best chance is to make Google Assistant leaps and bounds better in terms of understanding user intent and predicting user needs compared to the other digital assistants such that users will have no choice but to use Google Assistant because of its superiority in understanding and knowledge its user. We can illustrate this strategy using Google search as an example. Google is by far the dominant player in search on mobile and web. Even Apple users are heavily reliant on Google search (despite the fact that they might not be aware, given search in Siri, iOS, and Safari are all powered by Google). You ask anybody which search engine is the "best", and almost everyone will answer Google. However, translating this dominance in search into the consumer smart home is not so clear because consumers in the home are focused on accomplishing tasks - not necessarily searching for information. So, what can Google do to win in the consumer smart home? How can they convince users to multi-home or even switch away? How can they convince Alexa users to multi-home/switch in spite of Alexa's dominant install base? How can they convince Apple users to multi-home/switch if Assistant is not used in any other contexts like Siri is? (car, wearables, etc). One vector into the consumer home is also integrating Google Assistant in third party devices and/or through Samsung devices. However, this remains a tougher path than Alexa because Alexa already has such a massive advantage in terms of install base and tools for developer voice apps. Google's best bet then is to focus on building a technologically superior assistant that is better across not just search and knowledge, but all other first-party and third-party services, allowing deep integration with the entire google suite of applications and services. This will ensure that Google Assistant is the de facto assistant in the home much like Google is the de-facto search engine on mobile and web.

Ultimately, addressing question 3 will remain a huge challenge for all players. Luckily, I believe that consumers are still in the experimental stage and do not necessarily have confidence in which assistant is the "best" yet. Therefore, major players should focus on ensuring a perfect user experience on first-party tasks. Only then can they begin to generate increased awareness of assistant capabilities through word-of-mouth, advertising, and marketing efforts to drive further assistant usage and habituation.

Conclusion

Summary

This thesis explains how the evolution of voice as the next important personal computing platform will bring about fundamental shifts in the technology and personal computing industry. We began with a survey of the current landscape and the enabling market drivers as well as inhibitors that retard the advancement of digital voice assistants in the smart home. We then move towards a deeper understanding of consumer needs in the smart home over the next decade including hyper-personalized AI that anticipates and delivers more value to its users. This thesis also elucidates current major digital assistants' strategies – especially the current industry leaders in this space: Apple's Siri, Amazon's Alexa, and Google Assistant. The next section focused on making a series of informed predictions on where the industry is headed and what the characteristics of the smart home in 2030 will look like. Ultimately, it ends with an analysis on the key opportunities and risks for digital assistant companies and how they can create and also capture value to ensure sustained success for not only their digital assistants but their companies in the long-term.

In restricting the scope of our investigation to United States-based smart homes over the next decade, we conclude that the key players in the digital voice assistant space cannot solely focus on their current strategy which has for the most part consisted of increasing digital assistant penetration and amassing a large assistant install base. While having a large installed base is certainly helpful, in terms of data acquisition for its machine learning systems, it is not sufficient to ensure long-term sustained success in the market. Instead, what is proposed in this thesis is

that companies must focus on driving increased digital assistant usage and awareness of its capabilities amongst its users.

To drive usage amongst users, we analyze the current companies' strategies with respect to the capabilities of their assistants on numerous dimensions including privacy, user trust, third-party app development, and most critically, performance on first-party services. First party services, those services and apps which are native to the digital assistant, must perform as well or better than current screen and text-based methods of human computer interaction. Additionally, the behavior change required of users must be minimized in order to drive user adoption of voice assistants to accomplish those same screen-based tasks. Thus, the digital assistants that are able to perform most reliably and seamlessly on first-party services and that present the least burden for users to switch from touch-based modalities to using voice for accomplishing tasks will be critically important in this next phase of the digital assistant voice wars. Sustained, habit-forming digital assistant usage allows companies to build better, more context-aware, hyper-personalized assistants that consumers will trust with every aspect of their life, creating significant consumer switching barriers that will be the key determinant for long term digital assistant success.

Limitations

Given that the rise of digital voice assistants has only recently begun, there are a number of limitations that must be noted in the context of this thesis. They are explained below.

1) Larger global/macro economy conditions

The extent to which voice assistants succeed and when they will succeed may be severely impacted by economic conditions including but not limited to commoditization of hardware and the supply of raw goods/materials used for smart home devices, global economic conditions including labor forces, and availability of high bandwidth broadband connections. These are all factors that are critical to ensure the seamless usage of voice assistants in the smart home.

2) The progress of artificial intelligence and machine learning research

Much of this thesis assumes sustained improvements in AI and ML technologies which are at the very core of digital voice assistants. While the field of commercial voice assistants is quite young, AI/ML as employed in general commercial settings is not much

older. The success of voice assistants will rely heavily on the rate of progress of AI technologies.

3) Government regulation

Government's role in the successful adoption of digital voice assistants will have an outsized impact especially with regards to user data privacy laws. While this thesis mainly focused on digital assistants in the United States where data privacy regulations are immature and lax, we see extensive regulation already in place in many countries in Europe. The U.S. government will have a large role in the successful adoption of voice assistants for both hardware device makers and assistant firms themselves.

Recommendations

We conclude this thesis with important recommendations for the key voice assistant companies. The major recommendation for all major players is to focus on first-party services to drive increased digital assistant usage. This entails building the average users' awareness of what their voice assistants can actually achieve on first party tasks. Furthermore, voice assistant companies need to ensure reliability on first party tasks which builds user trust in their voice assistant. Trust then leads to increased voice assistant usage which in turn drives two key benefits – 1) better and more data to feed the voice assistant machine learning systems and 2) encourages habit-forming voice assistant usage by consumers.

For key company specific recommendations, Google must continue investing in a voice assistant that prioritizes understanding and personalization of its user. It should continue investing heavily into machine learning technologies which will allow them to build a smarter Google Assistant that is hyper-personalized to Google's users across its portfolio of Google products and services. This will allow Google Assistant to tightly integrate its wide array of Google services and keep users reliant on everything from maps navigation, to home automation, to email services, and media consumption. Building this all-encompassing and ever more complete profile of its users will drive ever higher competitive advantage in its core advertising strategy as Google gains an even better understanding of its users to target with advertising.

Apple's Siri strategy remains consistent with its overall core strategy to reduce outchurn of its customers in the Apple ecosystem. While Siri has become a sore spot for the technology giant in recent years, it must ensure that Siri does not fall too far behind Alexa and Assistant so as to cause users to defect from Apple's device ecosystem. Thus, Apple needs to ensure that it continues to build deep, "magical" integrations with all of its products and services to provide a seamless voice assistant experience with Siri as the connective tissue in the entire Apple device ecosystem.

Amazon, with its massive installed base of Alexa enabled products in the consumer smart home, finds itself in a very powerful position. Amazon must now find ways to translate this installed base advantage into a tangible long-term competitive advantage that further solidifies its leadership as the one-stop online destination for anything and everything. With deep expertise already across many domains including retail, delivery logistics, robotics, cloud computing, and even digital advertising, Amazon must continue driving Alexa voice assistant usage and foster a compelling voice ecosystem for users and app developers alike to lock in consumers on the Alexa voice platform. As users become habituated to Alexa as their daily personal assistant that does anything and everything in their home, Amazon will gain valuable insights on its users' purchasing and retail habits. Coupled with Amazon's extensive online/offline retail presence and superior operational capabilities, the Alexa platform will then reinforce Amazon's core business strategy of being the on-demand everything store for every consumers' material needs.

By following these sets of recommendations, the major voice assistant players can build context-aware, hyper-personalized digital assistants which users will entrust with increasingly varied and complex tasks. Hyper-personalized, conversational assistants that are always-on, readily accessible, and that users are critically reliant upon, erects high switching barriers for consumers which will be the key determinant in which digital assistant will capture the consumer market. As users gravitate towards their digital assistant of choice, companies must then leverage the data-driven insights gleaned from consumer voice assistant usage to reinforce their core strategic goals. Winning the voice war is critical for key players to sustain their businesses and for companies to thrive in the next decade and beyond.

Appendix

Human Factors Consideration for Voice-First Digital Assistants Study

Demographic Initial Survey

Demographic Information for Virtual Assistant Study

Date: / / Subject # _____

1. Sex (circle one) Male Female 2. Age (in years) _____

3. First language _____

4. Describe your English accent (e.g. British, Boston, Midwest, French-influenced)

5. How strong do you perceive your accent is to others? (rate 1 – 5 using scale below)

- Scale (1-5):
1. Neutral (no perceivable accent)
 2. Mild (a perceivable accent in some words)
 3. Moderate (perceivable accent in many words)
 4. Strong (speech is sometimes misunderstood)
 5. Very Strong (speech is often misunderstood)

6. What type of smartphone operating system(s) are you most comfortable with (iPhone, Android, other)?

7. What is your proficiency with a smartphone? (rate 1-5 using scale below)

- Scale (1-5): 1. Never used 2. Novice 3. Proficient 4. Highly Proficient 5. Expert

8. What virtual assistant system(s) have you used (Alexa, Siri, Google Assistant, Cortana, other)?

9. What is your proficiency with virtual assistant system(s) (Alexa, Siri, Google Assistant, Cortana, other)? (rate 1 – 5 using scale below)

- Scale (1-5): 1. Never used 2. Novice 3. Proficient 4. Highly Proficient 5. Expert

10. What is your current level of trust of the information when using a virtual assistant system(s) (Alexa, Siri, Google Assistant, Cortana, other)? (rate 1 – 5 using scale below)

- Scale (1-5): 1. Complete distrust 2. Low trust 3. Medium trust 4. High trust 5. Complete trust

Complete Question 11 after completing tasks

11. After completing the tasks, what is your new level of trust of the information when using a virtual assistant system(s) ? (rate 1 – 5 using scale below)

- Scale (1-5): 1. Complete distrust 2. Low trust 3. Medium trust 4. High trust 5. Complete trust

Recruitment Letter for Participation in Study

Study Recruitment Message

The message that will be contained within the email will be similar to:

“You are invited to participate in a research study conducted for the 16.453 Human Systems Engineering Course from the Massachusetts Institute of Technology (MIT). In this study, you will be asked to use a smart phone with voice command. Results from this study will be used to understand the effectiveness of voice commands and potential ways to improve these systems.

We hope to identify if any specific factors are strongly correlated to how well an individual can perform a task utilizing a digital voice assistant. The results of this study will be included in a project presentation and report for the Human Systems Engineering Course. The interview is voluntary, and the appropriate consents regarding collection and publication of gathered information will be obtained prior to the interviews take place. Please consider volunteering your time for this project.”

Procedure Used for Test Subjects

Procedure

Pre Subject Arrival

1. Book a conference room and ensure the conference room is quiet and does not have any distractions and has good internet
2. Ensure the 2 designated test observers are present
3. Identify which observer (O1) will be interacting with the test subject and noting the accuracy of the result and which observer (O2) will be noting the time
4. Ensure that the test phone, iPhone 6S plus is at least 50% charged, powered on
5. Reset phone to test settings:
 - a. Ensure the phone is connected to the wireless network and test that the phone has internet
 - b. Turn Bluetooth On
 - c. Go to “Settings > Siri & Search” and ensure both, and turning OFF both, “Listen for “Hey Siri”” and “Press Home for Siri”
 - d. Remove all alarms except the 12pm alarm
 - e. Delete all items in the “To Do” list except “Buy a Phone”
 - f. Close all running Apps in the phone by double tapping the Home button and swiping all the apps up
 - g. Ensure the location service “Map” is turned on.
6. Place the Phone facing the test subject
7. Place the Question Cards on the table facing down in the ordered sequence
8. Setup the timing system, spreadsheet recording system **Appendix RED** and any other system that will be needed
9. Invite the test subject to sit down, turn off any device that would interfere during the test (Smartphone, Smartwatch, computer, etc.) but not to interact with any test material

Pre Test Post Subject Arrival

1. Inform the test subject on the purpose of the test and what they need to do. Please read the section in **Appendix GREEN**
2. Provide the test subject with the “Consent Form” and request him to read through the form and ask any questions he has regarding it, and sign the form

3. Request the test subject to fill the “Demographic Information for Virtual Assistant Study” (except for the last question) and to ask any questions he has regarding it
4. Configure Siri by going to “Settings > Siri & Search”, and turning ON, “Press Home for Siri”. Next turn ON “Listen for “Hey Siri”” and train Siri to the user’s voice pattern
5. Read the introduction message and test procedure to the test subject from **Appendix BLUE**
6. For an example, have the test subject ask Siri for the current time by asking “Can you get the current time from Siri”
7. Ensure the test area is clear and ready for the test

During Test

Observers read/be familiar with this before beginning test

1. O1: Check with test subject and O2 that they are ready
2. O1: Tell the test subject to start the test
3. O2: Timing procedure
 - a. Time start: A subject flips the question card
 - b. Time end: A subject says "DONE" or “ABORT”
4. O1: If a subject attempts to interact with the test administrators, the subject shall be told to exercise their best judgement in accomplishing the task
5. O2: Enter time into the timesheet
6. O1: Judge the accuracy of the answer from Siri. If the subject has stopped the test in between, use your judgment to identify whether he did get an answer by this time or not and put a memo on the task as "Incomplete"
7. Once ready, repeat steps 1 through 6

Post Test

1. Ask the test subject to answer the final question in the “Demographic Information for Virtual Assistant Study”
2. Thank the test subject
3. Put the test phone for charging
4. Reset phone to test settings:

- a. Ensure the phone is connected to the wireless network and test that the phone has internet
- b. Turn Bluetooth On
- c. Go to “Settings > Siri & Search” and ensure both, and turning OFF both, “Listen for “Hey Siri”” and “Press Home for Siri”
- d. Remove all alarms except the 12pm alarm
- e. Delete all items in the “To Do” list except “Buy a Phone”
- f. Close all running Apps in the phone by double tapping the Home button and swiping all the apps up

Appendix RED

Spreadsheet for record results.

Appendix GREEN

The purpose of this test is to test how humans interface with Siri and the performance of Siri to the user.

Appendix BLUE

Introduction Message and Test Procedure

- You will be asked to perform 10 basic tasks using a smartphone virtual assistant system, in this case (Siri).
- You may start each task when you are told by the observer that they are ready.
- Each task will be listed on an individual note card (labeled by number) and turning over the notecard will indicate the start time for that task.
- ONLY interact with Siri VOCALLY to get an answer. Please do not use any other input method on the device.
- The card instructions are cues and form sentences as best as you can.
- You can make multiple attempts during each test until you are satisfied with the solution. When you are satisfied with your answer, say “DONE” to the observer, and the observer will stop the timer for that task.

- If you would like to give up on that test card, say “ABORT”. You may press the HOME button to stop Siri if it is giving an extended response.
- Please do not interact with either observer during the timed phase of each test. You may interact with them once the timed phase for the task has been completed.
- You may then turn over the next numbered notecard when told by the observer that they are ready and follow the same procedure.

Your task completion time will be recorded time to complete each task as well as the accuracy of the answer by Siri. Please do not try to rush the task and interact with the device comfortably.

Summary Data Collection

Subject	Time	Accuracy	Sex	Age	First Language	Native	Perceived	Access	Smartphone	Prof	Can Use	Var	A	S	P	Pr	Initial	Final	Post	Level	Change	In	Tr
1	167.62	30 F	22 Y	3	4 V	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	102.04	29 M	30 Y	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V	1	5 V
3	172.82	30 M	34 Y	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N	3	2 N
4	138.82	30 M	22 Y	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V
5	165.82	30 M	24 Y	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V	1	4 V
6	176.80	28 M	33 Y	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V
7	177.06	36 F	27 N	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V
8	103.73	30 M	33 Y	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N	5	5 N
9	226.67	27 F	34 N	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V
10	369.93	27 M	33 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N	5	3 N
11	147.77	23 F	30 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N	2	4 N
12	312.98	29 F	36 N	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V
13	164.66	29 M	35 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N	4	3 N
14	166.95	30 M	34 N	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V
15	179.07	28 M	35 Y	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M	1	4 M
16	163.24	25 M	44 Y	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N	2	3 N
17	211.96	27 M	29 N	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y
18	461.53	28 M	38 N	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V	4	4 V
19	168.44	36 M	25 Y	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N
20	445.36	24 F	31 N	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V
21	213.99	27 F	32 N	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V	2	4 V
22	162.29	29 M	28 Y	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N	1	4 N
23	173.16	36 M	30 N	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V	3	4 V
24	123.30	30 M	28 N	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y	1	4 Y
25	123.70	36 M	26 N	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V	2	5 V
26	694.86	18 M	32 N	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y	5	4 Y
27	141.68	36 M	38 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y	2	4 Y
28	269.30	30 F	31 N	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y	3	3 Y
29	163.51	36 M	31 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N
30	135.18	30 F	27 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N	3	5 N
31	131.85	28 M	37 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N	1	3 N

Filter for Hypotheses:
M 22-30 YO Y
F >30 YO N

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