Voice War: Hey Google vs. Alexa vs. Siri

On voice search, we are really excited about it. You know, I think it’s a very natural way for users to interact. And for voice, we expect voice to work across many different contexts. So we are thinking about it across phones, homes, TVs, cars, and, you know, trying to drive that ecosystem that way. And we want Google to be there for users when they need it.

— Sundar Pichai, CEO of Google

On January 13, 2018, Google’s CEO, Sundar Pichai, skimmed the headlines pouring out of the Consumer Electronics Show (CES), held in Las Vegas, Nevada. No press conference or news release went by without some mention of Google Assistant. Just one year prior, Amazon had dominated these same headlines with news that “Amazon’s Alexa Just Conquered CES 2017. The World Is Next.” This year was slightly different, Google Assistant made it onto almost every hardware spotlight at the show, determined to show how all of these products could work together. Prominent ads throughout the city featured “Hey Google,” the command used to wake up Google’s intelligent assistant. Pichai wanted the world to know that it should not count Google out of the voice wars.

By almost any measure, Google’s performance as a company in the past few years had been exceptional. At the close of 2017, Google’s parent company, Alphabet, had achieved one of the highest market values of any public company at $727B. In 2017, revenues for Alphabet totaled $110.9 billion, up 23% over 2016. Google’s core advertising business, at $95.4 billion, represented 86% of Alphabet’s sales in 2017 (see Exhibit 1). Pichai wondered how Google could replicated its success in search in the voice assistant space. Despite Google Assistant’s rapid adoption, Google faced stiff competition: Apple was the first to market with the launch of “Siri” in 2011 on the iPhone 4S, followed by Microsoft’s rollout of “Cortana” across the Windows ecosystem. However, it was Amazon that created a new market with the launch of a dedicated voice-enabled device: the Echo smart speaker powered by Amazon’s intelligent assistant, Alexa. As of April 2018, Amazon Echo captured 66.7% of U.S. smart speaker users compared to Google Home’s 29.5% share.

By June 2018, Google had aggressively expanded Google Assistant’s presence to more than 400 million devices, including smart speakers, phones, tablets, and watches. Some reports applauded the company’s success: “Google won the voice assistant popularity contest at CES. Your move, Alexa.”

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How could Google capitalize on the success and momentum out of CES? What strategic moves would allow Google to build out its platform to compete with Amazon as well as the growing global competition? Would voice be a core or ancillary technology for Google moving forward?

**Google’s History**

Google co-founders Larry Page and Sergey Brin met in 1995 at Stanford University. While working on their dissertations, Page and Brin created an algorithm that used an index to sort web pages by relevance. Two years later, they decided to refine this search engine and named it “Google,” a derivation from the mathematical term “googol.” The term was rumored to reflect the founders’ mission to organize the infinite amount of information on the internet. In 2000, Google built AdWords as a pay-per-click, keyword-targeted advertising service, and their advertising revenues enabled the company to reach profitability. After bringing on former Novell CEO, Eric Schmidt as Google’s new CEO, Google launched a successful IPO (ticker: GOOGL) in 2004, raising $2 billion.

Over the next decade, Google launched new products and made a series of strategic acquisitions, including mobile OS maker Android, online video platform YouTube, and smart thermostat maker Nest. As the product lines grew, Page and Brin restructured the company and formed Alphabet, Inc. in October 2015 to increase transparency and better delineate its business units. Page explained that the new structure allowed Alphabet’s companies to have independence, and “we also like that it means alpha-bet (Alpha is investment return above benchmark), which we strive for!” Page took on the role of CEO of Alphabet and promoted Sundar Pichai to CEO of Google.

Pichai joined Google in 2004 and led product management on software products, including Chrome OS, Android, and Gmail. As CEO of Google, Pichai earned a reputation for championing artificial intelligence when he declared in an annual all-company memo: “We will move from mobile first to an AI-first world [...] a world where computing becomes universally available—be it at home, at work, in the car, or on the go—and interacting with all of these surfaces becomes much more natural and intuitive, and above all, more intelligent.” Pichai’s biggest decision as CEO had been to set up two new Google divisions, cloud computing and hardware. In the cloud business, Pichai bet that AI-equipped tools would set Google apart from its main rivals. The hardware division introduced a diverse line of products ranging from the Google Home Mini & Max smart speakers to the Pixel line of phones, Pixelbook (laptop), Pixelbook Pen and Pixel Buds (earphones). All of these products featured integration with Google Assistant.

**Google Assistant**

In May 2016, at their annual developer conference, Pichai first introduced the Google Assistant for public use: “We think of it as a conversational assistant. We want users to have an ongoing, two-way dialogue with Google. We want to help you get things done in your real world and we want to do it for you, understanding your context, giving you control of it. We think of building each user their own individual Google.”

**Intelligent Assistants**

Intelligent assistants had become commonplace in premium tier smartphones and other assistant-enabled devices by 2018 (see Exhibit 3 for installed base figures across competitors). Intelligent assistants (also known as virtual or voice assistants) were computer software programs that translated conversational text or spoken language requests into completed services. By early 2017, Android users...
conducted 20% of searches by voice through Google Assistant instead of text. By 2020, estimates projected that 50% of all searches would be voice searches, signaling a world where intelligent assistants played an ever increasing role in users’ lives.

A trigger, such as “Hey, Google” or “Alexa” or “Siri,” activated the intelligent assistant on certain devices. The assistant filtered out distracting audio signals (voice echoes, background noise, the device’s own loudspeaker) in order to capture the user request. This request was then converted to text and run through a natural language processing algorithm on the cloud for analysis. Natural language processing included the breakdown of phrases into intents (what is the request’s purpose?) and entities (does the request include a date, time or a contact?). These intents and entities were used to access a database of possible responses, which was then converted into an audio clip issued back to the user. Over time, intelligent assistants became smarter as more data fed into the algorithm.

Three primary technological advancements enabled the growth of intelligent assistants. Access to data was no longer a hurdle given the amount of information generated on the internet and mobile networks. Many companies, such as Netflix, sponsored competitions to encourage labelling of data or usage of data for recommendation systems. In addition, computer scientists had made major breakthroughs in machine learning (ML), a specific AI sub-category that improved task performance with increased access to contextual experience and data. In 2009, Nvidia’s Graphics Processing Units (GPUs), originally developed for video games, achieved the processing power capabilities needed to create and train deep neural networks, which were ML computing systems loosely modeled on the human brain. These three factors together led to the explosion of machine learning, which enabled many of the fields associated with modern AI capabilities, including computer vision, speech recognition, and natural language processing. Google had invested heavily in AI and had started building its own Tensor Processing Units (TPUs) to compete with GPUs and to focus specifically on neural network machine learning.

**Competition in the Intelligent Assistant Landscape**

Google Assistant initially debuted on Google’s messaging app Allo in 2016 and was exclusive to the Pixel smartphone for a period before becoming more widely available on Android devices. To speed adoption, Google positioned Google Assistant across multiple devices and channels, which included preloading Google Assistant on Android smartphones and launching a Google Assistant app on iOS. As a result of these efforts, Google Assistant accounted for 46% of all smartphones equipped with an intelligent assistant by May 2018. Google Assistant grew from being available on just one device in one language in 2016 to being available on multiple devices with translations available in 22 languages by 2018. The tech giant predicted that the Google Assistant would be available in 52 countries and support over 30 languages by the start of 2019.

In addition, Google started to open up the Google Assistant ecosystem in December 2016. The company launched “Actions on Google”, a platform allowing services enabled by third-party developers. Google’s Software Development Kit (SDK) allowed third-party hardware to run Google Assistant, and Google incentivized developers to build actions for the platform through competitions and prizes. Google kept tight control over which actions were approved on Google Assistant and added to the ecosystem gradually over time. In early 2018, Google Assistant had over a million conversational action-based services enabled, but only 1,830 voice actions (e.g. “Hey Google, dim the lights”). Notable manufacturers such as Sony and Panasonic partnered with Google to make Google Assistant accessible on their own devices, such as smart speakers and TVs.
Google worked aggressively to grow its assistant’s market share, but there were several companies vying to be the dominant player in the emerging intelligent assistant market.26

Apple  Apple was first to market with its voice-activated intelligent assistant, Siri, which it launched in October 2011 with the release of the iPhone 4S. Siri was a voice-activated intelligent assistant that Apple had acquired the previous year.27 (See Exhibit 2a for Apple financial data.) Apple maintained a closed ecosystem, making Siri available only for Apple products until 2016, when it opened up its ecosystem to third-party applications.28 However, Apple restricted integration to specific application categories, which included voice calling, ride-hailing, messaging and search. Apple was renowned for its strict stance on protecting consumer privacy, and tagged Siri searches with random user identifiers to protect consumer privacy and stored tagged data for only six months before deleting it. Observers noted that this decision reduced Apple’s ability to use the data to evaluate software updates and improve Siri’s functionality.29 According to some analysts, Siri’s technology paled in comparison to other smart assistants: a 2017 study of the accuracy of answers to questions showed that Siri answered 62.2% of questions correctly, while Google Assistant, Alexa and Cortana were all above 80%.30 Thanks to the iPhone’s massive installed base, however, Siri was the most widely used in terms of unique monthly users in 2017, with 41.1 million users. By 2018, Siri was also accessible in 21 languages in 36 countries.31

Amazon  Alexa, Amazon’s cloud-based voice technology, had its roots in the technology of a little-known British company called Evi.32 Evi launched its voice assistant in 2012 and was positioned as a competitor to Apple’s Siri before Amazon acquired Evi that same year. Initially, Amazon planned to leverage Evi’s technology to build an artificial speech-based book reader.33 This narrow vision later evolved into an idea to create a new platform that would be powered by a combination of Amazon Web Services (AWS), speech recognition, and high-quality speech synthesis and would be tied to an affordable piece of dedicated hardware, ultimately producing the Alexa-powered Amazon Echo Smart Speaker, which launched in late 2014. The next year, Amazon announced the Alexa Skills Kit (ASK) – a collection of self-service APIs and tools that made it easy for third-party developers to create new Alexa skills. This open platform strategy accelerated the number of Alexa skills to about 5,000 by the end of 2016 and over 25,000 by the end of 2017, far more than its rivals.34 (See Exhibit 4.) Amazon offered a wide variety of skills such as playing games such as Jeopardy, ordering an Uber ride, and asking about the weather and news. However, Alexa had limited availability across phones and tablets and as of 2018, it was available only on the Amazon Fire, HTC U11, and the Essential phone. Additionally, it was available as an application for Android and iOS. Alexa was available in over 80 countries and supported 4 languages.35 (See Exhibit 2b for Amazon financial data)

Microsoft  In April 2014, Microsoft launched its voice enabled digital assistant, called Cortana, as part of an update to Microsoft’s mobile operating system. In 2015 and 2016, Microsoft expanded Cortana to iOS and Android through mobile applications.36 In May 2017, Microsoft publicly launched the Cortana Skills Kit for developers looking to build new features and apps for Cortana on desktop, mobile, Xbox, and the newly-announced Cortana-powered smart speaker launching in fall 2017. As of January 2018, Microsoft Cortana had 235 skills, representing a 305% growth in the number of skills in the last 6 months of 2017.37 However, many major brands that had created skills for other intelligent assistants had not created skills for Cortana. Some developers claimed the certification process was inefficient and less clear than those offered by Amazon and Google.38 In May 2017, Microsoft announced that 500 million Windows 10 devices were integrated with Cortana, with 145 million monthly active users of Cortana worldwide and 60 million MAUs in the U.S.39 As of March 2018, Cortana was available in 13 countries and supported 8 languages.40
Samsung  Samsung Electronics was a multinational electronics company headquartered in South Korea. In 2017, Samsung led the overall global smartphone market with 18% market share, selling a wide variety of smartphones that spanning a range of price points. In 2016, Samsung acquired Viv, a voice assistant start-up from the makers of Siri, for integration with Samsung’s products. Samsung further developed its AI voice assistant (renamed “Bixby”) to work across Samsung devices. As of 2018, Bixby became the standard on Samsung’s high-end Android phones, which also supported Google Assistant.

Voice start-ups  By 2018, a number of smaller players had entered the voice market such as X.Ai, Ozlo and Mycroft. Mycroft, an open source software and hardware AI platform, raised a total of $1.75M in seed funding to help realize its vision. Mycroft’s open sourced approach allowed users to develop hardware and software on top of the platform to explore more use cases for the voice AI technology. Mycroft had landed a partnership with Mozilla to help the company build out its deep search library for speech-to-text transcription. The CEO of Mycroft, John Montgomery’s vision focused on flexibility and customization: “The advantage of working with our technology is it can be customized, and the companies can build a user experience that represents their brand.”

Competition Grows in China

By early 2018, China had emerged as the major locus of competition to U.S. tech giants, including in the intelligent assistant market. China boasted over 100 companies that had entered the race to capture a share of the voice assistant industry. The Chinese companies spent aggressively on research and development for their versions of voice-activated devices, and some had even expanded to the U.S. market. Perhaps of most concern to Google were Alibaba, Baidu, and Tencent, given their strategic assets and the progress they had already made.

Alibaba Group Holdings  Alibaba unveiled its intelligent assistant called AliGenie in mid-2017. AliGenie offered much of the same functionality as Amazon’s Alexa, such as ordering from Tmall, smart home control, weather, news, music, etc. AliGenie’s voiceprint recognition feature offered security by only allowing authorized users to place online orders. Later in 2017, Alibaba launched an open-developement platform at its annual Computing Conference. By May 2017, AliGenie had over 200 applications, of which less than 50 were developed by Alibaba.

Baidu  The dominant internet search operator in China, Baidu launched the Duer app—a mobile based virtual AI assistant—in 2015. Two years later, Duer OS, an open AI operating system, was launched at CES in January 2017. According to Baidu, DuerOS had accumulated more conversation-based skill sets than any company in the world—10 major domains and over 100 sub-domains of conversational skills. The company also launched a solution called TurnKey, which provided backend support for manufacturers to speed up enterprise demand for AI integration. One of Baidu’s major partnerships was with Xiaomi to bring DuerOS to Xiaomi’s IoT platform of 85 million connected devices.

Tencent Holdings  Tencent, creator of popular messaging and social media app called WeChat, had been working on its AI assistant called Xiaowei, which was powered by data from Tencent’s sprawling ecosystem (WeChat, TenCent Music, Tencent Video, and YouTu Labs). Xiaowei supported the usual applications such as weather reports and music requests and came with voice recognition, facial recognition, and an SDK. In the future, Xiaowei would also be able to conduct multilingual translation and object detection.
Leading Chinese hardware makers such as Huawei and Xiaomi were also developing their own intelligent voice assistants. Xiaomi launched its own smart speaker in July 2017 and began adding its intelligent voice assistant, called Xiao Ai, to its phones and other devices over the course of the next year. While Xiao Ai was aimed at the Chinese market, Xiaomi announced in May 2018 that it would integrate Google Assistant into several of its smart home devices for the U.S. market. Huawei, the world’s third-largest smartphone manufacturer, was also reported to be working to enter the market of voice-enabled digital assistants as of early 2017, primarily focused, like Xiaomi, at the Chinese market. By mid-2018 it had not yet brought its assistant to market.

**Voice Wars: Intelligent Assistants Move Beyond Mobile**

After launching their own respective intelligent assistants, all the major players began focusing on manufacturing their own voice-enabled devices and/or partnering with other companies to increase their user base. More broadly, the push towards industry dominance led players with intelligent assistants to move beyond initial use cases. With a crowded landscape, Google faced large well-funded domestic and international technology giants on the one hand and ambitious lean upstarts on the other. Google had to think beyond the initial use cases and ecosystems for the Google Assistant to achieve Pichai’s vision to make voice and the Google Assistant ubiquitous.

**Smart Speakers**

Smart speakers represented the major hardware platform for voice assistants beyond smartphones and other mobile devices. Amazon catalyzed the discussion regarding the potential applications of intelligent assistants with the launch of the Echo, a smart speaker that became publicly available in July 2015. This first smart speaker entrant opened up the realm of possibilities for voice assistants beyond phones, tablets, and computers. In March 2016, Amazon followed up the Echo Dot (retail price: $50), a smaller version of the original Echo. A few months later, Amazon went on to release an entire suite of hardware products powered by Alexa (see Exhibit 5 for Echo’s product portfolio). In June 2017, Amazon released the Echo Show (retail price: $230) with a seven-inch screen to integrate voice and visual user interfaces for the first time. This device enabled users to watch videos and view product details on potential purchases in conjunction with voice commands.

In November 2016, Google followed suit and launched its own smart speaker, the Google Home (retail cost: $129) powered by Google Assistant. A year later, Google released two new sizes: the Google Home Mini (retail cost: $49) and the Google Home Max (retail cost: $399) in time for the 2017 holiday season (see Exhibit 6 for Google Home product portfolio). Google proclaimed to have sold more than one Google Home (largely mini speakers) per second in the fourth quarter of 2017. Over the holiday season, Amazon responded by dropping the price of its Echo Dots to $29.99, despite estimates which suggested an Echo Dot cost $34.87 to produce.

By the time Apple entered the market in February 2018 with the HomePod (retail cost: $349), Amazon had 66.6% of the market (down from 71% in 2017), Google 29.5%, and other players only 8.3%. Apple tried to distinguish itself from the competition by boasting sound quality akin to Sonos or Bose and marketed the HomePod as a complement to Apple Music and iTunes. In response, Google announced partnerships with higher quality sound and smart screen display products made by JBL, Lenovo, LG and Sony, which further expanded its smart speaker features.

Microsoft, Mycroft, and big Chinese manufacturers also sought to play in the smart speaker market. Microsoft first entered the smart speaker market through a partnership with Harman Kardon (the home and car audio equipment manufacturing company), releasing Invoke (retail cost: $199) in
October 2017. In early 2018, Microsoft announced another strategic partnership with Xiaomi to integrate Cortana into the Yeelight speaker (retail cost: $30) and the Mi AI speaker (retail cost: $45) for the low-end Chinese market. On the other hand, Mycroft developed two smart speakers: the Mark I and the Mark II. The Mark I was targeted towards developers as a device that consumers could hack and customize for their needs. The Mark II was the consumer facing product equivalent. In the meantime, Alibaba launched its smart speaker, called the Tmall Genie X1 in July 2017, and Baidu launched its own voice-activated smart speaker, called the Raven H, in November 2017. Tencent followed in April 2018 with its Tingting smart speaker.

In the U.S. smart speaker sales jumped from around 7 million units in 2016 to over 27 million in 2017, and analysts forecast the number to reach nearly 57 million in 2019 before tapering off. (See Exhibit 7 for rate of smart speaker penetration of the U.S. market). Globally, smart speaker sales accelerated in early 2018. Since none of the companies reported actual smart speaker sales, estimates were all over the map. One analyst estimated 9.2 million devices were shipped in the first quarter of 2018, up from 2.4 million in Q1 of the previous year. Amazon remained the market leader with 43.6% share, although that represented a significant drop from the previous year. Google was second with 26.5% share, while Alibaba edged out Apple for the third spot, with 7.6% share to Apple’s 6.0%. A different analyst put Google ahead of Amazon in Q1, with a 36% share to Alexa’s 27.7% share. Overall, forecasts predicted over 56 million smart speakers with voice assistant capabilities would be shipped worldwide in 2018, with one out of six Americans owning a smart speaker.

Connected Home

While much of the attention paid to smart speakers focused on features such as playing music, online shopping, and getting updates on news, weather, and sports, Google and its competitors positioned their smart speakers as the potential operating system of the broader connected home ecosystem, acting as the single point of control for the wide array of smart devices found in a connected home, whether media and entertainment, lighting, climate control, or security.

An estimated 433 million smart home devices were shipped in 2017 with sales estimated at over $162 billion. Analysts forecast that the number of devices shipped would increase to nearly 940 million by 2022, generating $270 billion in revenue. Video entertainment remained the largest category followed by home monitoring (including security), lighting, and thermostats. Despite this growth, the complexity of the connected home, with devices from hundreds or thousands of vendors, had hindered adoption. By early 2018 there were several competing standards for in-home smart device communications, which varied in terms of power management, range, speed, and security. While many products supported multiple standards, the lack of a shared standard, coupled with consumer concerns about privacy and security, and price, had slowed adoption of smart home technology.

In early 2018, Google Home had nearly 600 voice apps enabled on the device and more than 1,500 smart home device partners from over 200 brands, including August Home, Philips Hue, and Logitech. Google also strengthened its growing home product collection, shipping newer versions of its Nest and Chromecast with Google Assistant integration built-in. For example, users could say to their Nest Camera, “Ok Google, show me the entryway on my TV.” Nest Hello, Google’s doorbell helper, could use its “Familiar Faces” feature to recognize individuals and broadcast that information using the Assistant to Google devices in the house. Google was also more deliberate about where its own services were available. For example, Google had blocked Amazon from integrating YouTube on Echo devices and Amazon’s FireTV.
For online shopping, Google partnered with big box retailers such as Target, Walgreens, Costco, and Walmart as part of the Google Express shopping service. Express shopping powered by Google Assistant enabled users to order items from a range of retailers using simple voice commands. It represented the first time that Walmart had distributed its products outside its own company channels. As part of its partnership with Google, Walmart made all data about the customer’s purchase history available to Google.

To further customize the user experience, Google Assistant emphasized its Voice Match capabilities which gave more personalized help across shared devices for users. Voice Match recognized individual devices and voices, and responded with individual specific news preferences, music (from Google Play/YouTube integrations) or matched voices to specific partner apps. For example, it could link individuals to their Netflix profiles. Netflix teamed up with Google to create interactive games promoting new shows with Google Assistant enabled devices. Google pursued similar entertainment partnerships to create games on the Home devices with Disney and other family friendly brands.

Like Google, Amazon positioned the Echo as the operating system that powered the connected home. In online shopping, the Echo represented another entry point into Amazon’s retail platform. Amazon planned to take advantage of data on consumer shopping habits so that Alexa could prompt users to restock previously purchased items. Analysis showed that owning an Echo increased spending on Amazon’s e-commerce platform: an average household that that used Amazon spends about $1,000 annually, a household with the company’s Prime premium membership spent about $1,300, and a household with an Echo spent $1,700.

Amazon’s presence in the connected home went beyond just e-commerce. It launched APIs such as the Smart Home Skill API and Lighting API and forged partnerships with home device manufacturers such as Philips, Honeywell, Wink, Whirlpool, and Lutron. Alexa could integrate with any third-party hardware manufacturer’s products. Further, Amazon incentivized developers with monetary awards if developers created skills that drove high customer engagement. In early 2018, Alexa worked with more than 4,000 devices from 1,200 unique brands. To further bolster its ecosystem, Amazon acquired Ring, a video doorbell maker, and integrated the product with Alexa to expand its home security product line to compete with Nest.

In the entertainment and music space, Amazon had its own subscription service through its Prime membership program, competing with Spotify, Apple, and Netflix. Additionally, device manufacturers such as Sony, Logitech Harmony, and BroadLink had already utilized Alexa’s Smart Home Skill API to make hands-free TV and media player control possible via Alexa. Dish, a satellite TV provider, also integrated Alexa into its technology to provide a hands-free experience. Amazon’s own devices - Fire TV stick and Fire TV streaming player - had Alexa built in so that users could launch apps like Netflix and play movies, TV shows, and music.

Apple had been the first to build a connected ecosystem by integrating Siri across its product portfolio such as their laptops and entertainment devices like Apple TV. Apple’s Home iOS application shipped with iPhones and enabled Apple consumers to control partner smart home devices with ease. Underlying the application was Apple’s HomeKit developer protocol, first released in 2014, which had over 200 partnered accessories in May 2018. Despite these efforts, due to its delay in opening up Siri to developers and Apple’s stringent compatibility testing for third-party applications, Siri had the fewest number of partnerships and skill integrations.
Cars and other hardware platforms

With the fierce battle for voice adoption and dominance, Google turned its attention to other ecosystems that could benefit from having a voice-enabled intelligent assistant. It faced competition in those arenas as well. Android Auto, which brought features from an Android device into a car’s in-dash display, partnered with Audi and Volvo in 2017 and had integrated with Google Assistant to enable hands-free interactions during driving. Common commands included asking for directions, responding to messages, and location-based reminders.

Amazon had its own strategy to enter the automotive market. It entered into individual deals with car manufacturers such as BMW, Ford, Genesis, and Mercedes. To spread its voice recognition technology to multiple car manufacturers at once, Amazon announced Alexa Onboard at CES 2018 and positioned it as a new voice system that integrated with a car’s infotainment system. Amazon commanded 11.5% market share in the infotainment and telematics industry, and entered into a partnership with Panasonic with the hope of bringing Alexa to cars everywhere.

As with Siri, Apple had been one of the earlier entrants in the transportation space. Apple launched CarPlay in 2015, a smart dashboard for automobiles controlled by Siri. As of 2017, some 200 models including Audi, BMW, VW and Ford offered Siri via the CarPlay software. CarPlay helped users access their contacts, make calls, listen to voicemail, get directions for navigation, and play music all through Siri’s voice interface.

In January of 2017, Microsoft and Nissan announced they were working together on Microsoft’s Connected Vehicle Platform utilizing Azure, Cortana, and Office 365. Microsoft and BMW also announced a similar partnership where drivers would access Cortana through a dashboard screen to view news, upcoming appointments, reminders, to-do lists, and more.

Google’s Pixel Buds (earbuds) were also optimized for Google Assistant on-the-go, enabling directions or reminder setting. Integration with Google Lens (an image-recognition powered camera) on the newest phones allowed users to look up landmarks, albums, sights combining conversational question and answer with visual context to deliver a seamless experience. Similarly, Apple’s AirPod wireless headphones, released in late 2016, were integrated with Siri, largely replacing physical controls with voice commands.

Enterprise

Beyond the consumer space, Google and its key competitors had valuable enterprise assets and businesses that represented a massive opportunity for intelligent assistants. The growing cloud arena was a valuable one for Google and its biggest competitors in 2018, but it wasn’t clear how each player would tie their intelligent assistant to their enterprise assets.

Google While Google had made significant progress towards Pichai’s vision for the assistant “to help get things done,” Pichai noted that “even in the US, 60% of small businesses don’t have an online booking system set up and we think AI can help with this problem.” In May 2018, at Google I/O, the company’s annual developer conference, Pichai revealed Google Duplex, which helped “connect users to businesses in a good way.” Google Assistant responded to user requests and made phone calls in the background to hair salons or restaurants and created appointments or reservations by mimicking real human conversations. On the Google Cloud Platform, Google provided the Google Actions API to help manage interactions with Google Assistant for developers and larger businesses. Pichai believed Google Assistant and the company’s head start in AI abilities would set Google’s cloud business apart from competitors: “We view our state-of-the-art machine learning and AI technologies as a
differentiator for the cloud platform. I think it will help propel the platform forward. We want it to be possible for hundreds of thousands of developers to use machine learning.” Google also opened up a new investment program for early-stage startups, which provided access to the Google Cloud platform as they built new creative experiences on top of the Google Assistant and attempted to maximize the synergies between the two services. 

Apple Traditionally a consumer focused company, in 2017 Apple launched Business Chat, a platform that allowed businesses to offer real-time customer support. Primarily a chat bot, to help business users answer questions with text, Apple also enabled Siri to ask questions, schedule appointments, and make purchases by talking directly to Business Chat users in the Messages app. Business Chat was built for shopping with purchases completed through Apple Pay. Amongst other features, Business Chat also allowed customers to schedule events using their personal calendars. This allowed users to talk to Siri and directly order a pizza from their favorite restaurant, if the restaurant was on the Business Chat platform. Observers believed merchants would one day have their own “Siri” that could help customers with common questions but through a voice user experience. Any business could register and integrate their customer service platforms, in addition to developing their own custom features, like a separate Messages app to complete certain tasks. By 2018, companies such as Discover, Hilton, The Home Depot, Lowe’s, Marriot, Wells Fargo, and a few others used the Business Chat feature.

Microsoft Enterprise was an area of strength for Microsoft, which hoped to make Cortana into an important business tool. In October 2015, Microsoft announced Cortana’s integration with LinkedIn: Cortana could remind a user of an upcoming meeting with a richer set of information about the meeting attendees pulled from attendees’ LinkedIn profiles, including profile photos, job titles, and companies. In March 2018, Microsoft announced Cortana’s upcoming integration with Microsoft Teams, a chat-based workspace for Office 365 designed to help businesses boost collaboration and productivity. Microsoft Teams users could use voice commands to join a meeting and make a call, and Microsoft Translator provided inline message translation to understand team members that spoke different languages. Microsoft’s cloud computing service, Azure, was enabled natural language and speech through Cortana.

Amazon In May 2016 at Microsoft’s CEO Summit, Amazon CEO Jeff Bezos approached Microsoft CEO Satya Nadella in an unforeseen move about a partnership to integrate Alexa and Cortana voice assistants. The cross-platform integration would allow for consumers using an Echo speaker to access Microsoft work calendars and emails, for example, while a consumer using Cortana on a Windows 10 PC could access Amazon shopping or smart-home devices. The integration had yet to launch as of April 2018, despite a target roll-out date of end of 2017. Amazon had its own cloud computing platforms through their subsidiary Amazon Web Services. Announcements for an AWS Alexa skill (“Alexa, ask AWS what’s launched at …”) and Alexa for Business powered by AWS (e.g., configure conference rooms with Alexa) were released in November 2017, but AWS’s future plans with Alexa were unknown.

Challenges

While the progress made over the previous few years showed that the voice assistant landscape was ripe with opportunity, the space was also fraught with challenges that Google (and its competitors) needed to address.
Privacy Concerns

As consumers opened their homes to data collection with smart home devices, Google, Amazon, Apple and others had access to a new and valuable source of consumer data. This created significant privacy concerns at a time when major hacks, leaks, and exploitation of personal information contributed to a climate of increased consumer concern and heightened government scrutiny. In March 2018 it was revealed that data analytics firm Cambridge Analytica gained unauthorized access to 87 million users’ information, which further spurred the conversation around data privacy.94

Devices such as the Google Home and Amazon Echo responded to their “wake” words—“Ok, Google” or “Alexa” respectively. Once activated, the smart assistant recorded what a user said and sent the recording to the backend servers, where the spoken input was analyzed and stored. While only supposed to listen in response to their wake words, several Google Mini devices shortly after release were found to be listening to their owners and recording all the time.95 While Google addressed the issue immediately, such incidents raised concern about how much information was being collected, who had access to the data, and how it would be used in the future. Privacy concerns about Alexa were heightened when, in May 2018, Amazon acknowledged that one of its Echo devices had inadvertently recorded parts of a couple’s conversation and sent the recording of the conversation to a person in the owner’s contact list. According to Amazon, the device misinterpreted parts of the conversation as a series of commands instructing it to begin recording and to send the message to a contact.96

Another privacy concern was that voice-enabled assistants embedded in smart speakers could be controlled by any person who had access to the device, which enabled that person to carry out tasks that involved sensitive information. For example, theoretically anyone could make a purchase using stored payment information or retrieve personal information if they were close enough to the device. Amazon provided the option to set a 4-digit pin code for its speakers, like Apple had done for the iPhone, but even this did not provide foolproof security.97 By late 2017, both Alexa and Google Assistant had added the ability to distinguish between different voices and link those voice to personalized accounts. However, neither had deployed that ability to restrict access to smart speakers to only authorized voices, citing the need to maintain flexibility to respond to visitors in the home.98

As the voice wars were heating up, the European Union prepared to enforce a sweeping new data protection law called the General Data Protection Regulation (GDPR) in May 2018. Under this new law, companies would have to obtain a user’s explicit and affirmative consent in order to store and process personal data.99 Additionally, companies would not be allowed to hold data for longer than is necessary, and a user could ask for data to be deleted at any time. Fines for violations could be as high as 4% of a company’s global revenue. With impending regulation, voice-powered devices would soon require privacy disclosures and explicit opt-in consent before recording and processing any personal information.

Technology Constraints

Accuracy in the context of multiple users and various environments represented a significant hurdle to voice assistants reaching ubiquity in consumers’ lives. While advancements in machine learning helped the development of voice as a UI, companies still faced technical issues. For example, AI-enabled voice assistants struggled to distinguish user commands from background voices and ambient noise. In a home, it was generally easy for a user to speak to their intelligent assistant with low levels of interference. However, a desired level of accuracy was a challenge in noisier environments like urban areas. Dubbed the “cocktail party” problem, machine learning researchers had found breakthroughs that would allow AI assistants to separate voices. One such breakthrough, in May 2017, was created by
researchers at the Mitsubishi Electric Research Laboratory. Their AI platform managed to
distinguish multiple voices and reconstruct what each person was individually saying. The system
could properly identify two people speaking into a single microphone with up to 90% accuracy; with
three people speaking, the accuracy dropped to 80%. However, this advancement still represented
an improvement: previous technology could only accurately distinguish two voices at 50% accuracy.

By 2017, Google had achieved a 95% accuracy rate in its speech recognition technology—an
impressive feat, but not one without its own set of challenges. These hurdles would continue to evolve
as consumers and regulators joined the conversation and shared their perspective. These hurdles raised
questions for Google’s future success and underpinned how Google thought about its future in the
voice industry.

Toy or Productive Tool?

While Google, Amazon, Apple, Microsoft and others had opened up their voice platforms for third
parties to write new and exciting applications, the vast majority of “skills” created for voice were going
unused (see Exhibit 8). Most consumers played music or listened to the news, but did not take
advantage of the tens of thousands of specialized applications.

Google’s Future in Voice

In light of Google’s success in early 2018, Pichai appeared confident about the prospects of Google’s
future with voice. Google had been gaining market share, but by some measures, it was still a distant
second to Amazon. Pichai insisted that:

“[Google] assistant is a two-way conversation, a natural dialogue between our users and Google to
help them get things done in the real world. The assistant will be universal, it will be available when
the users need it to help them. And our goal is to build a personal Google for each and every user.”

Despite Pichai’s optimism about the future of voice and Google Assistant for the company, Pichai’s
team had not yet created a monetization strategy for voice. Amazon announced a monetization strategy
for Alexa in May 2018, allowing skills developers to offer in-skill purchases, i.e. selling premium digital
content within an Alexa skill. Amazon received 30 percent of each sale. Google had explored
monetizing voice search with advertisements. In one experiment in March of 2018, consumers would
ask Google Assistant a question and then hear something like, “By the way, Disney’s live action Beauty
and The Beast opens today.” The test soon ended due to user complaints and negative press.

Pichai was making a big bet without a clear business model. If consumers used voice to search, and
got their answers with a voice response, how would that impact Google’s core search business? According to some analysts, Google had one of the best, if not the best, voice technology. Should Google keep the technology in-house to drive Google services and Google products? Should Google license the technology broadly to third parties? How would the future of voice intersect with the growing number of Alphabet’s businesses?
### Exhibit 1a  Alphabet, Inc. Select Financial Data (2009–2017)

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</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>23,651</td>
<td>29,321</td>
<td>37,905</td>
<td>46,039</td>
<td>55,519</td>
<td>66,001</td>
<td>74,989</td>
<td>90,272</td>
<td>110,855</td>
</tr>
<tr>
<td>Cost of sales</td>
<td>8,844</td>
<td>10,417</td>
<td>13,188</td>
<td>17,176</td>
<td>21,993</td>
<td>25,313</td>
<td>28,164</td>
<td>35,138</td>
<td>45,583</td>
</tr>
<tr>
<td>Research and development</td>
<td>2,843</td>
<td>3,762</td>
<td>5,162</td>
<td>6,083</td>
<td>7,137</td>
<td>9,832</td>
<td>12,282</td>
<td>13,948</td>
<td>16,625</td>
</tr>
<tr>
<td>Selling, general, and administrative</td>
<td>3,652</td>
<td>4,761</td>
<td>7,313</td>
<td>8,946</td>
<td>10,986</td>
<td>13,982</td>
<td>15,183</td>
<td>17,470</td>
<td>19,765</td>
</tr>
<tr>
<td>Operating income (loss)</td>
<td>8,312</td>
<td>10,381</td>
<td>12,242</td>
<td>13,834</td>
<td>15,403</td>
<td>16,874</td>
<td>19,360</td>
<td>23,716</td>
<td>28,882</td>
</tr>
<tr>
<td>Net income (loss)</td>
<td>6,520</td>
<td>8,505</td>
<td>9,737</td>
<td>10,737</td>
<td>12,733</td>
<td>14,136</td>
<td>16,348</td>
<td>19,478</td>
<td>12,662a</td>
</tr>
</tbody>
</table>

Accounts receivable, net: 3,178 4,252 5,427 7,885 8,882 9,383 11,556 14,137 18,336
Inventories: -- -- 35 505 -- -- 491 268 749
Net property, plant, and equipment: 4,845 7,759 9,603 11,854 16,524 23,883 29,016 34,234 42,383
Total assets: 40,497 57,851 72,574 93,798 110,920 129,187 147,181 167,497 197,295
Total liabilities: 4,493 11,610 14,429 22,083 23,611 25,327 27,130 28,461 44,793
Total shareholders’ equity: 36,004 46,241 58,145 71,715 87,309 102,860 120,331 139,036 152,502
Cash dividends paid: -- -- -- -- -- -- 491 268 749
Number of employees: 19,835 24,400 32,467 53,861 47,756 53,600 61,814 72,053 80,110
Gross margin: 62.6% 64.5% 65.2% 62.7% 60.4% 61.6% 62.4% 61.1% 58.9%
R&D/sales: 12.0% 12.8% 13.6% 13.2% 12.9% 14.9% 16.4% 15.5% 15.0%
SG&A/sales: 15.4% 16.2% 19.3% 19.4% 19.8% 21.2% 20.2% 19.4% 17.8%
Return on sales: 27.6% 29.0% 25.7% 23.3% 22.9% 21.4% 21.8% 21.6% 11.4%
Return on assets: 14.4% 13.2% 11.7% 10.4% 9.4% 8.8% 8.7% 9.4% 9.9%
Return on equity: 20.3% 20.7% 18.7% 17.8% 16.6% 14.2% 14.6% 15.0% 8.7%
Stock price low: $141.51 $217.03 $236.74 $212.96 $348.10 $497.19 $490.91 $672.66 $796.89
Stock price high: $313.30 $315.73 $323.69 $387.57 $561.04 $615.04 $798.69 $839.00 $1086.49
P/E ratio at period-end: 40.03 24.13 22.02 22.17 32.20 28.23 34.85 29.00 35.21
Market value at period-end: 169,521 200,791 184,710 248,461 396,788 359,747 478,168 560,588 752,662

Source: Casewriter, using data from CapitalIQ, Thomson One, and company filings.


### Exhibit 1b  Alphabet, Inc. Revenue by Segment ($ millions)

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Google advertising</td>
<td>22,888</td>
<td>28,236</td>
<td>36,531</td>
<td>43,686</td>
<td>50,547</td>
<td>59,056</td>
<td>67,390</td>
<td>79,383</td>
<td>95,375</td>
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<tr>
<td>Google properties</td>
<td>15,722</td>
<td>19,444</td>
<td>26,145</td>
<td>31,221</td>
<td>37,422</td>
<td>45,085</td>
<td>52,537</td>
<td>63,785</td>
<td>77,788</td>
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<tr>
<td>Google network member properties</td>
<td>7,166</td>
<td>8,792</td>
<td>10,386</td>
<td>12,465</td>
<td>13,125</td>
<td>13,971</td>
<td>15,033</td>
<td>15,598</td>
<td>17,587</td>
</tr>
<tr>
<td>Google other revenue</td>
<td>761</td>
<td>1,085</td>
<td>1,374</td>
<td>2,353</td>
<td>4,972</td>
<td>6,945</td>
<td>7,154</td>
<td>10,080</td>
<td>14,277</td>
</tr>
<tr>
<td>Total Google segment revenue</td>
<td>23,650</td>
<td>29,321</td>
<td>37,905</td>
<td>50,175</td>
<td>55,519</td>
<td>66,001</td>
<td>74,544</td>
<td>89,463</td>
<td>109,652</td>
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<tr>
<td>Other Bets revenue</td>
<td>445</td>
<td>809</td>
<td>1,203</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Alphabet revenue</td>
<td>23,650</td>
<td>29,321</td>
<td>37,905</td>
<td>50,175</td>
<td>55,519</td>
<td>66,001</td>
<td>74,544</td>
<td>90,272</td>
<td>110,855</td>
</tr>
</tbody>
</table>

Source: Casewriter, compiled from company filings.
Exhibit 2a  Apple Inc., Selected Financial Information, FY 2009–2017 (in millions of dollars, except for number of employees and stock-related data)

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Net sales</td>
<td>42,905</td>
<td>65,225</td>
<td>108,249</td>
<td>156,508</td>
<td>170,910</td>
<td>182,795</td>
<td>233,715</td>
<td>215,639</td>
<td>229,234</td>
</tr>
<tr>
<td>Cost of sales</td>
<td>25,683</td>
<td>39,541</td>
<td>64,431</td>
<td>87,846</td>
<td>106,606</td>
<td>112,258</td>
<td>140,089</td>
<td>131,376</td>
<td>141,048</td>
</tr>
<tr>
<td>Research and development</td>
<td>1,333</td>
<td>1,782</td>
<td>2,429</td>
<td>3,381</td>
<td>4,475</td>
<td>6,041</td>
<td>8,067</td>
<td>10,045</td>
<td>11,581</td>
</tr>
<tr>
<td>Selling, general, and administrative</td>
<td>4,149</td>
<td>5,517</td>
<td>7,599</td>
<td>10,040</td>
<td>10,830</td>
<td>11,993</td>
<td>14,329</td>
<td>14,194</td>
<td>15,261</td>
</tr>
<tr>
<td>Operating income (loss)</td>
<td>11,740</td>
<td>18,385</td>
<td>33,790</td>
<td>55,241</td>
<td>48,999</td>
<td>52,503</td>
<td>71,230</td>
<td>60,024</td>
<td>61,344</td>
</tr>
<tr>
<td>Net income (loss)</td>
<td>8,235</td>
<td>14,013</td>
<td>25,922</td>
<td>41,733</td>
<td>37,037</td>
<td>39,510</td>
<td>53,394</td>
<td>45,687</td>
<td>48,351</td>
</tr>
<tr>
<td>Accounts receivable, net</td>
<td>5,057</td>
<td>9,924</td>
<td>11,717</td>
<td>18,692</td>
<td>20,641</td>
<td>27,219</td>
<td>30,343</td>
<td>29,299</td>
<td>35,673</td>
</tr>
<tr>
<td>Inventories</td>
<td>455</td>
<td>1,051</td>
<td>776</td>
<td>791</td>
<td>1,764</td>
<td>2,111</td>
<td>2,349</td>
<td>2,132</td>
<td>4,855</td>
</tr>
<tr>
<td>Net property, plant, and equipment</td>
<td>2,954</td>
<td>4,768</td>
<td>7,777</td>
<td>15,452</td>
<td>16,597</td>
<td>20,624</td>
<td>22,471</td>
<td>27,010</td>
<td>33,783</td>
</tr>
<tr>
<td>Total assets</td>
<td>47,501</td>
<td>75,183</td>
<td>116,371</td>
<td>176,064</td>
<td>207,000</td>
<td>231,839</td>
<td>290,479</td>
<td>321,686</td>
<td>375,319</td>
</tr>
<tr>
<td>Total liabilities</td>
<td>15,861</td>
<td>27,392</td>
<td>39,756</td>
<td>76,615</td>
<td>118,210</td>
<td>123,549</td>
<td>119,355</td>
<td>128,249</td>
<td>134,047</td>
</tr>
<tr>
<td>Total shareholders’ equity</td>
<td>31,640</td>
<td>47,791</td>
<td>76,615</td>
<td>157,854</td>
<td>318,754</td>
<td>307,290</td>
<td>161,124</td>
<td>143,437</td>
<td>141,272</td>
</tr>
<tr>
<td>Cash dividends paid</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>2,488</td>
<td>10,564</td>
<td>11,126</td>
<td>11,561</td>
<td>12,150</td>
<td>12,769</td>
</tr>
<tr>
<td>Number of employees</td>
<td>34,300</td>
<td>46,600</td>
<td>60,400</td>
<td>72,800</td>
<td>80,300</td>
<td>92,600</td>
<td>110,000</td>
<td>116,000</td>
<td>123,000</td>
</tr>
<tr>
<td>Gross margin</td>
<td>40%</td>
<td>39%</td>
<td>41%</td>
<td>44%</td>
<td>38%</td>
<td>39%</td>
<td>40%</td>
<td>39%</td>
<td>39%</td>
</tr>
<tr>
<td>R&amp;D/sales</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>3%</td>
<td>4%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>SG&amp;A/sales</td>
<td>10%</td>
<td>8%</td>
<td>7%</td>
<td>6%</td>
<td>6%</td>
<td>7%</td>
<td>6%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Return on sales</td>
<td>19%</td>
<td>21%</td>
<td>24%</td>
<td>27%</td>
<td>22%</td>
<td>22%</td>
<td>23%</td>
<td>21%</td>
<td>21%</td>
</tr>
<tr>
<td>Return on assets</td>
<td>18%</td>
<td>19%</td>
<td>22%</td>
<td>24%</td>
<td>16%</td>
<td>17%</td>
<td>21%</td>
<td>15%</td>
<td>14%</td>
</tr>
<tr>
<td>Return on equity</td>
<td>31%</td>
<td>35%</td>
<td>42%</td>
<td>43%</td>
<td>31%</td>
<td>34%</td>
<td>46%</td>
<td>37%</td>
<td>37%</td>
</tr>
<tr>
<td>Stock price low a</td>
<td>$11.17</td>
<td>$27.18</td>
<td>$44.36</td>
<td>$58.43</td>
<td>$55.01</td>
<td>$70.51</td>
<td>$89.47</td>
<td>$114.76</td>
<td></td>
</tr>
<tr>
<td>Stock price high</td>
<td>$30.64</td>
<td>$46.67</td>
<td>$60.96</td>
<td>$100.72</td>
<td>$82.16</td>
<td>$119.75</td>
<td>$134.54</td>
<td>$118.69</td>
<td>$177.20</td>
</tr>
<tr>
<td>P/E ratio at period-end</td>
<td>33.5</td>
<td>21.3</td>
<td>14.6</td>
<td>12.1</td>
<td>14.1</td>
<td>17.1</td>
<td>11.4</td>
<td>13.9</td>
<td>18.4</td>
</tr>
<tr>
<td>Market value at period-end</td>
<td>177,767</td>
<td>282,375</td>
<td>372,321</td>
<td>560,013</td>
<td>472,269</td>
<td>616,453</td>
<td>664,970</td>
<td>616,362</td>
<td>885,669</td>
</tr>
</tbody>
</table>

Source: Casewriter, compiled using data from Capital IQ and ThomsonOne, as well as company filings.
### Exhibit 2b  Amazon, Inc., Select Financial Data, 2009–2017

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</tr>
</thead>
<tbody>
<tr>
<td>Total revenue</td>
<td>24,509</td>
<td>34,204</td>
<td>48,077</td>
<td>61,093</td>
<td>74,452</td>
<td>88,988</td>
<td>107,006</td>
<td>135,987</td>
<td>177,866</td>
</tr>
<tr>
<td>Cost of sales</td>
<td>18,978</td>
<td>25,561</td>
<td>37,288</td>
<td>45,971</td>
<td>54,181</td>
<td>62,752</td>
<td>71,651</td>
<td>88,265</td>
<td>111,934</td>
</tr>
<tr>
<td>Research and development</td>
<td>1,240</td>
<td>1,734</td>
<td>2,909</td>
<td>4,564</td>
<td>6,565</td>
<td>9,275</td>
<td>12,540</td>
<td>16,085</td>
<td>22,620</td>
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<tr>
<td>Selling, general, and administrative</td>
<td>3,060</td>
<td>4,397</td>
<td>6,864</td>
<td>9,723</td>
<td>12,647</td>
<td>16,650</td>
<td>20,411</td>
<td>27,284</td>
<td>38,992</td>
</tr>
<tr>
<td>Operating income (loss)</td>
<td>1,180</td>
<td>1,406</td>
<td>862</td>
<td>745</td>
<td>178</td>
<td>2,233</td>
<td>4,186</td>
<td>4,106</td>
<td></td>
</tr>
<tr>
<td>Net Income (loss)</td>
<td>902</td>
<td>1,152</td>
<td>631</td>
<td>(39)</td>
<td>274</td>
<td>(241)</td>
<td>596</td>
<td>2,371</td>
<td>3,033</td>
</tr>
<tr>
<td>Cash, cash equivalents, and short-term investments</td>
<td>6,368</td>
<td>8,762</td>
<td>9,576</td>
<td>11,448</td>
<td>12,447</td>
<td>17,416</td>
<td>19,808</td>
<td>25,981</td>
<td>30,986</td>
</tr>
<tr>
<td>Accounts receivable, net</td>
<td>988</td>
<td>1,587</td>
<td>2,571</td>
<td>3,817</td>
<td>4,767</td>
<td>5,612</td>
<td>5,654</td>
<td>8,339</td>
<td>13,164</td>
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<tr>
<td>Inventories</td>
<td>2,171</td>
<td>3,202</td>
<td>4,992</td>
<td>6,031</td>
<td>7,411</td>
<td>8,299</td>
<td>10,243</td>
<td>11,461</td>
<td>16,047</td>
</tr>
<tr>
<td>Total assets</td>
<td>13,813</td>
<td>18,797</td>
<td>25,278</td>
<td>32,555</td>
<td>40,159</td>
<td>48,474</td>
<td>54,505</td>
<td>64,747</td>
<td>83,402</td>
</tr>
<tr>
<td>Total liabilities</td>
<td>8,556</td>
<td>11,983</td>
<td>17,521</td>
<td>24,383</td>
<td>30,413</td>
<td>43,764</td>
<td>51,363</td>
<td>64,117</td>
<td>103,601</td>
</tr>
<tr>
<td>Total shareholders’ equity</td>
<td>5,257</td>
<td>6,654</td>
<td>7,757</td>
<td>5,192</td>
<td>9,746</td>
<td>10,741</td>
<td>13,384</td>
<td>19,285</td>
<td>27,709</td>
</tr>
<tr>
<td>Cash dividends paid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of employees</td>
<td>24,300</td>
<td>33,700</td>
<td>56,200</td>
<td>88,400</td>
<td>117,300</td>
<td>154,100</td>
<td>230,800</td>
<td>341,400</td>
<td>566,000</td>
</tr>
<tr>
<td>Gross margin</td>
<td>22.6%</td>
<td>22.3%</td>
<td>22.4%</td>
<td>24.8%</td>
<td>27.2%</td>
<td>29.5%</td>
<td>33.0%</td>
<td>35.1%</td>
<td>37.1%</td>
</tr>
<tr>
<td>R&amp;D/sales</td>
<td>5.1%</td>
<td>5.1%</td>
<td>6.1%</td>
<td>7.5%</td>
<td>8.8%</td>
<td>10.4%</td>
<td>11.7%</td>
<td>11.8%</td>
<td>12.7%</td>
</tr>
<tr>
<td>SG&amp;A/sales</td>
<td>12.5%</td>
<td>12.9%</td>
<td>14.3%</td>
<td>15.9%</td>
<td>17.3%</td>
<td>18.7%</td>
<td>19.1%</td>
<td>20.1%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Return on sales</td>
<td>3.7%</td>
<td>3.4%</td>
<td>1.3%</td>
<td>-0.1%</td>
<td>0.4%</td>
<td>-0.3%</td>
<td>0.6%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Return on assets</td>
<td>6.7%</td>
<td>5.4%</td>
<td>2.4%</td>
<td>1.5%</td>
<td>1.3%</td>
<td>0.2%</td>
<td>2.3%</td>
<td>3.5%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Return on equity</td>
<td>22.8%</td>
<td>19.0%</td>
<td>8.6%</td>
<td>(0.5%)</td>
<td>3.1%</td>
<td>(2.4%)</td>
<td>4.9%</td>
<td>14.5%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Stock price low a</td>
<td>$47.63</td>
<td>$105.80</td>
<td>$160.59</td>
<td>$172.00</td>
<td>$245.75</td>
<td>$284.00</td>
<td>$285.25</td>
<td>$474.00</td>
<td>$747.70</td>
</tr>
<tr>
<td>Stock price high</td>
<td>$145.91</td>
<td>$185.65</td>
<td>$246.71</td>
<td>$264.11</td>
<td>$405.63</td>
<td>$408.06</td>
<td>$696.44</td>
<td>$847.21</td>
<td>$1213.41</td>
</tr>
<tr>
<td>P/E ratio at period-end</td>
<td>79.23</td>
<td>72.91</td>
<td>91.27</td>
<td>NM</td>
<td>NM</td>
<td>NM</td>
<td>NM</td>
<td>171.80</td>
<td>298.20</td>
</tr>
<tr>
<td>Market value at period-end</td>
<td>55,751</td>
<td>77,185</td>
<td>81,667</td>
<td>123,985</td>
<td>164,734</td>
<td>164,638</td>
<td>276,384</td>
<td>394,840</td>
<td>692,249</td>
</tr>
</tbody>
</table>

Source: Casewriter, using data from Capital IQ, Thomson One, and company filings.
Exhibit 3  Current and Forecast Installed Base of Intelligent Assistants


Exhibit 4  Voice App Skill Growth, by Platform

### Exhibit 5  Amazon’s Product Portfolio with Alexa Integrations

<table>
<thead>
<tr>
<th>Price</th>
<th>$49.99</th>
<th>From $99.99</th>
<th>$149.99</th>
<th>$129.99</th>
<th>$229.99</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overview</strong></td>
<td>Add Alexa to any room</td>
<td>Room filling sound with six finishes/fabrics</td>
<td>Includes a built-in smart home hub</td>
<td>Stylish and compact Echo with a screen</td>
<td>Optimized for visuals and room filling sound</td>
</tr>
<tr>
<td>Screen size</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>2.5” screen</td>
<td>7” screen</td>
</tr>
<tr>
<td>Speaker size</td>
<td>0.6” speaker</td>
<td>2.5” woofer and 0.6” tweeter</td>
<td>2.5” woofer and 0.8” tweeter</td>
<td>1.4” speaker</td>
<td>Dual 2.0” stereo speakers</td>
</tr>
<tr>
<td>Dual-speakers with room-filling sound, powered by Dolby</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Play video from Amazon Video and more</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Built-in hub for simple setup of compatible connected smart home devices</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Control smart home devices</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Streaming Wi-fi music (including Amazon Music, Spotify, Pandora, and more)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Free audio calls to U.S., Mexico, Canada</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

## Exhibit 6  Google’s Product Portfolio with Google Assistant Integrations

<table>
<thead>
<tr>
<th></th>
<th>Google Home Mini</th>
<th>Google Home</th>
<th>Google Home Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td>$49</td>
<td>$129</td>
<td>$399</td>
</tr>
<tr>
<td><strong>Speaker</strong></td>
<td>360 sound</td>
<td>2” driver and 2” passive radiators</td>
<td>Two 4.5 in woofers and two 0.7 in tweeters</td>
</tr>
<tr>
<td><strong>Ports and connectors</strong></td>
<td>Micro USB port</td>
<td>DC Power Jack</td>
<td>USB-C</td>
</tr>
<tr>
<td><strong>Connectivity</strong></td>
<td>Wi-fi and Bluetooth</td>
<td>Wi-fi and Bluetooth</td>
<td>Wi-fi and Bluetooth</td>
</tr>
<tr>
<td><strong>Multi-room audio</strong></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Control smart home devices</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Streaming Wi-fi music (including YouTube Music, Spotify, Pandora, Google Play)</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Exhibit 7  Technology Device Penetration in the U.S., Years from Inception (as % of population)


Exhibit 8  Smart Speakers, Top Use Cases, 2018

Endnotes


