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IoT opportunity in the world of semiconductor companies

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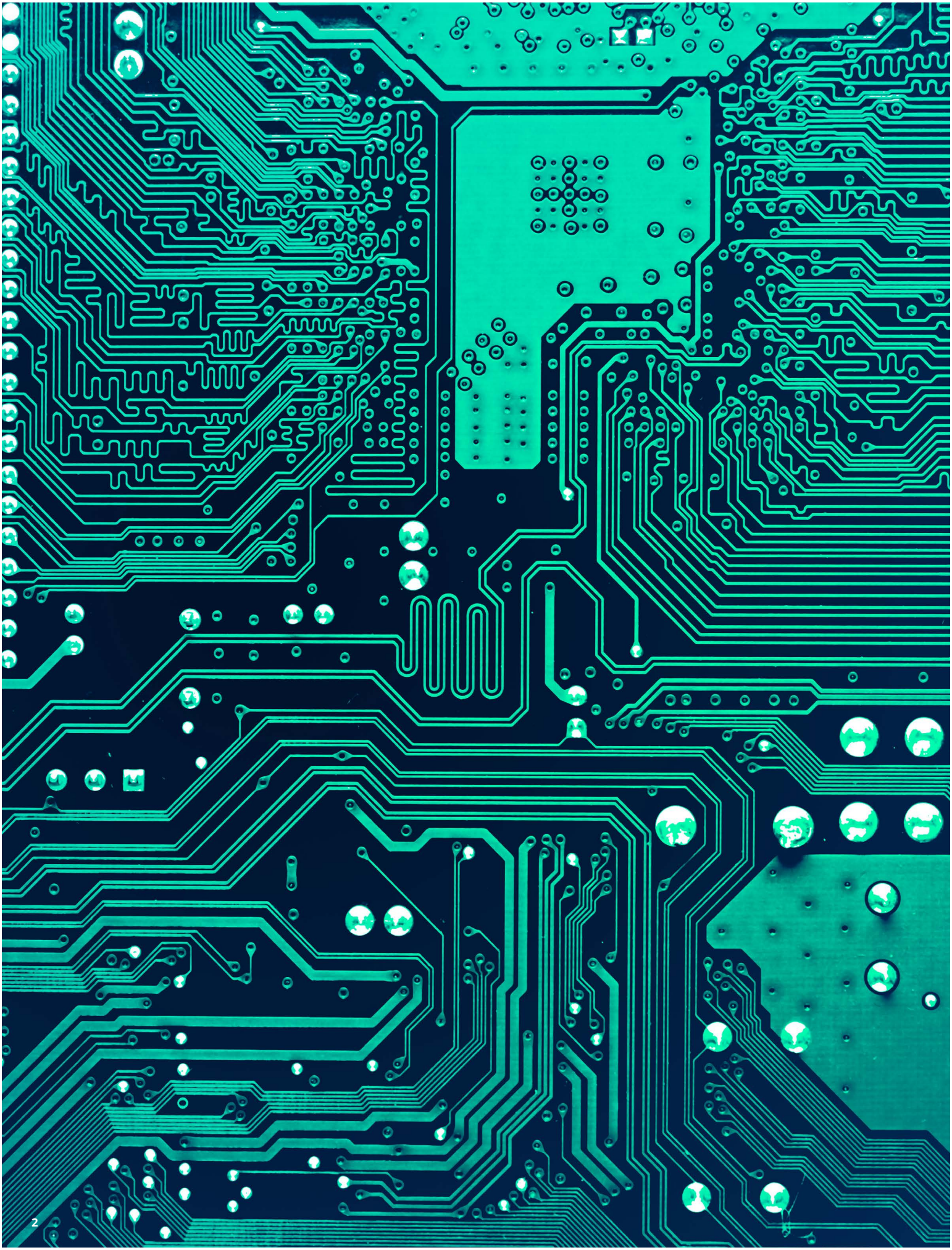


The opportunity: Semiconductor companies in the future

They could be immersed in powering a world of IoT

How do you create shareholder value when your product is so heavily commoditized that it's nearly impossible to make high margins on it? You build an ecosystem to provide solutions, and the Internet of Things (IoT) brings semiconductor companies that opportunity, with markets ripe for innovation and growth.

So, what's driving the shift? Semiconductors form the underpinning of all the electronics we use in our daily lives. From the alarm clock and microwave that help us get our day started, to the cell phone and laptop that enable our workday—much of what we depend on is powered by semiconductor chips. Yet, semiconductor companies are at a critical junction. Leaders require new strategies to grow their businesses in smart ways.

The power of three

Top trends forcing change

The semiconductor industry has been affected by three major trends in recent years that have been difficult hurdles to overcome:

- *Product performance may be peaking:* Moore's law states that the number of transistors, and hence the performance, in a dense integrated circuit will double approximately every two years, and it has been true for a long time. Computers have become smaller and faster over the past few decades lending credence to the theory. However, in recent years this phenomenon has slowed. Peak performance of semiconductors may be starting to level out.
- *Low economic profit in the industry:* Most players in the industry have struggled to consistently generate profit. Competition is fierce, and when a product is a commodity it can shrink margins. In some cases, profits made over a period of some years on in-demand products tend to be lost on future products that fail to take off.
- *Disruption in technology value chain:* Many semiconductor companies experiencing a decrease in profitability have uncovered more value from integration, software, and service than from the sale of chips. Many companies now have more software engineers than hardware engineers, but they don't get paid for these costs by their customers. Essentially, they are offering more and getting less, which is only sustainable for so long.

Where there's challenge, there's opportunity

Take advantage of IoT markets

In order to overcome the effect of these trends, a large number of semiconductor companies have taken measures to reinvent themselves. The leaders in the industry are making moves to:

- **Improve margins through merger and acquisitions** and thus benefit from the resultant economies of scale.
- **Grow their product portfolio,** thus moving into more profitable market segments such as IoT.

There is tremendous opportunity for semiconductor companies to provide value to their end customers via IoT markets. These devices and sensors are going to play a critical role in collecting and processing data across a variety of industries. They will likely bring forth new services and create cost reduction opportunities. They can forge insights into new discoveries and help us find quality issues faster and improve output. And in some industries, like health care and automotive, they could even save lives. The ability for an IoT sensor or device to sense its surrounding, communicate its state, and process the collected data to determine the best response to its environment holds extraordinary promise. The projected size of the market is equally impressive.

IoT semiconductor spending is projected to be $34 billion in 2020.[1] At the same time, IoT electronics solution spending is projected to reach $572 billion presenting semiconductor companies the opportunity for revenue growth other than from device sales.[2] However, to realize the revenue growth benefits, semiconductor companies should adapt their product development and go-to-market strategy for the IoT market.

How will semiconductor companies devise IoT strategies?

Semiconductor companies can no longer simply be component providers to create value in this market. They have to understand the entire IoT stack's requirement, and in some cases, create an end-to-end solution that facilitates market adoption. A typical IoT stack with representative electronic subsystem is illustrated in figure 1. The left-hand box is typically the device that contains the sensors. It could be a mobile phone or a medical device that captures a person's heartbeat. Both the device and the IoT platform it communicates with have the capability to analyze and organize the data received.

The IoT platform also has the capability of interpreting the data and sending analytics up through an application that provides insights and alerts to people or providers. Security is a critical component at every step of the journey, from the time the data is collected to the time it is served up in the application. There are opportunities for semiconductor companies to provide products and services in four key areas of the stack—Sense, Analyze, Communicate, and Security—as illustrated in the diagram. There are also greenfield opportunities to provide services in other areas of the stack. Samsung has already taken steps in this direction by offering the ARTIK platform, which includes cloud platform, analytics offerings, and ease of cloud integration.

While the opportunity is large, the IoT market presents entry challenges to semiconductor companies. These challenges range from a fast-changing and fragmented market, to security and privacy issues, to industry-specific go-to-market nuances. Semiconductor companies can embrace IoT strategies by:

Building a business ecosystem

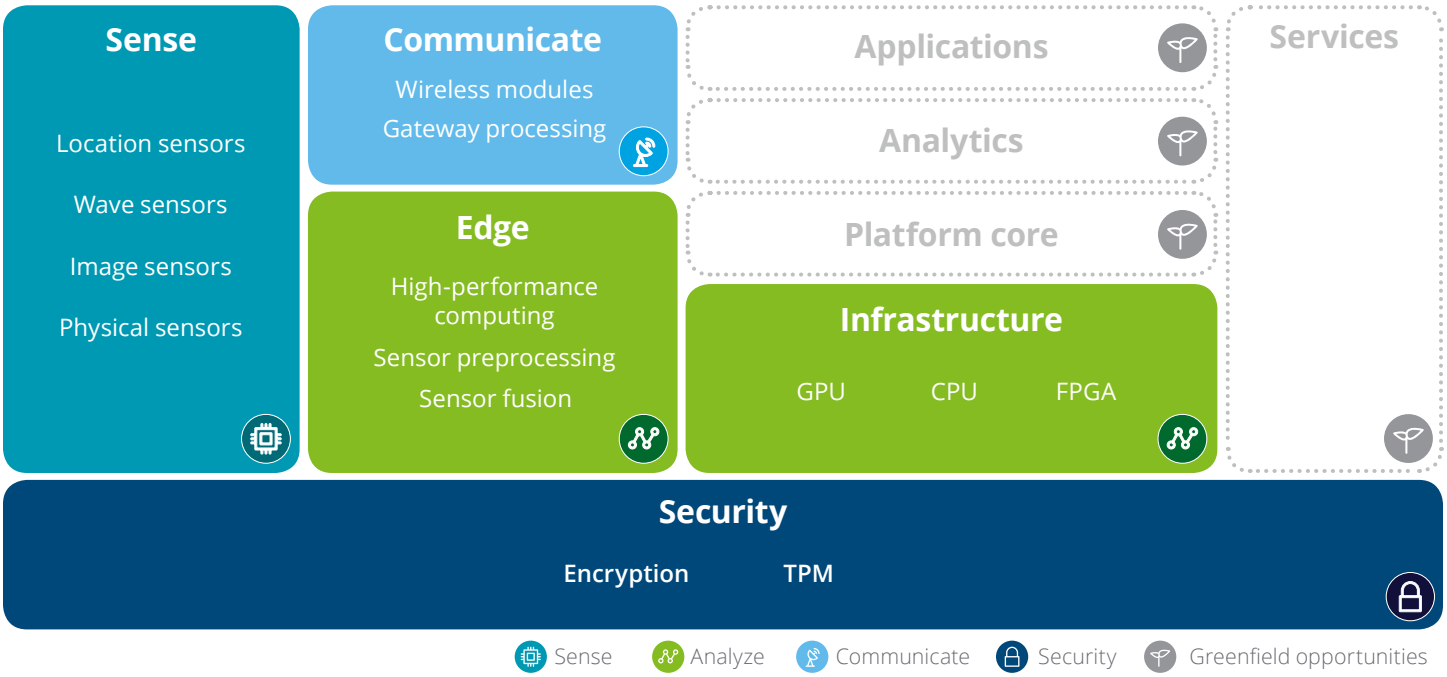
In order to provide an end-to-end IoT solution, we need device manufacturers, communication hardware, connectivity protocols, cloud providers, IoT platforms, analytics and system integrators, etc. On top of that, IoT is a nascent and fragmented market with different end-customer needs. It is impossible for a single company to possess all the technologies. The nature of the IoT market calls for an ecosystem of companies that share a vision and have complementary assets and skills. Semiconductor companies could build such an ecosystem and strive to be the control point, as they architect and help catalyze, enable, and manage the whole solution jointly developed by the ecosystem partners.

Enabling ecosystem partners

A sustainable partner ecosystem creates a win-win situation for all parties involved. To form a successful ecosystem, semiconductor companies should understand, develop, and nurture the partners to enable their growth. This may require providing them technical, business, and financial support.

Semiconductor companies also may need to adjust the product strategy. Besides making trade-offs between power, function, form factor, and security, semiconductor companies should consider additional features or products to enable IoT ecosystem partners. Such offerings might include a software development kit (SDK) tailored to the IoT developer, or enabling ease of connectivity to cloud platforms, analytics apps, and system integration services.

Figure 1. IoT stack diagram



Creating a digital sales platform

The best way to build a business ecosystem is to build it around a concrete customer case. However, the IoT markets are so fragmented with varying end-user requirements in different industry verticals and use cases. It is nearly impossible to sell to such a broad and fragmented market without more digital platform to bring the providers of different components of the end-to-end solution together. An integrated digital sales platform will help enable the partners to work together from opportunity identification to solution development. For example, an intelligent opportunity management will help identify opportunities and determine which partners to pull into the deal whether they be cloud platform operators, data service operators, applications and analytics developers, third-party system integrators, or consultants. Such integrated deals could allow semiconductor companies to blanket what is now a highly fragmented IoT market with a lot of sub-segments, giving them a distinct advantage and their customers a single point of contact.

Ensuring security and privacy

Security and privacy can make or break the adoption of IoT products. Challenges include not only hardware vulnerabilities, but also security gaps created during integration and implementation of IoT systems as well as those created during remote device access, communication, and management. Features and solutions that mitigate these issues often include software-based API security. Such security measures can authenticate and authorize data movements between devices. Create a hardware-based trusted platform and execution strategy to ensure authenticity of firmware. Use a built-in encryption module with public key infrastructure and multi-factor authenticated access. To ensure the gaps are covered, none of this activity should be done in isolation. Work together with partners to uncover and solve potential security issues.

Customizing by industry need

In addition to these common themes, nuances in each vertical require specific product and go-to-market strategies. To sell offerings into these markets, it's important to understand what customers are trying to achieve. Semiconductor companies should be particularly interested in IoT opportunities in the following markets: industrial, automotive, smart cities, health care, and consumer. Let's take an in-depth look at these sectors, the market opportunity for semiconductor companies, and ways to win.

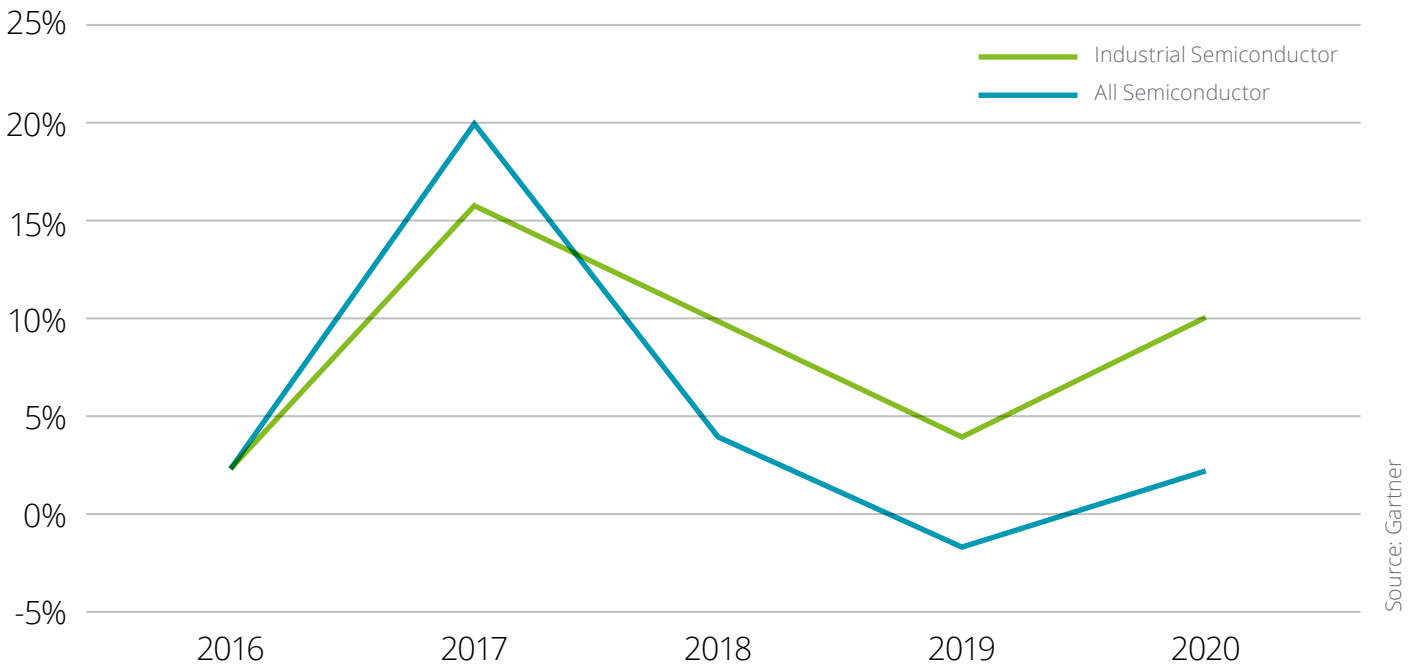
Industrial market overview

This industry is red hot

The industrial semiconductor sector has grown to $33 billion market in 2015, and it's expected to grow to $49 billion in 2020, at a CAGR of 9.8 percent (roughly two times that of total semiconductor growth).[3]

Out of the $49 billion, IoT semiconductor sale comprises $8.4 billion.[4] There's a tremendous amount of opportunity in this sector if semiconductor companies can harness the IoT products and services customers need.

Figure 2. YoY revenue growth of industrial semiconductor vs. all semiconductor



Meet the fourth industrial revolution

IoT opportunities and sensor data create a smart factory

The industrial sector is the poster child of IoT, and it is undergoing disruption with the advent of the digital age. IoT solutions often create a communication network in the industrial sector that extends far beyond the walls of the factory and out in the field to suppliers, distributors, and logistical organizations serving the enterprise. This network helps fuse physical realities with new technologies creating interconnected digital enterprises that are capable of better informed decision making. Sensors track individual products as they make their way through a plant, onto trucks, and out into warehouses, creating a digital record along the way. Alerts are sent to supervisors if machines sense an abnormality arising. Performance data is collected in the field and algorithms identify quality issues a year earlier than historical processes of discovery would have allowed. The phenomenon has given rise to the next industrial revolution, now referred to as Industry 4.0. The factories that embrace Industry 4.0 are referred to as smart factories.

The ability to adjust and learn from data in real time can make the smart factory more responsive, proactive, and predictive. It also enables the organization to avoid operational downtime and other productivity challenges.[5] Where does IoT in the industrial sector hold the most promise for semiconductor companies?

The main applications are within the factory

Asset performance management (APM)

Unplanned downtime is costly for manufacturers. APM is an approach to increase asset control, reliability, and availability while reducing unnecessary maintenance. APM connects disparate data sources and uses advanced analytics to turn that data into actionable insights while fostering collaboration and knowledge management across the organization.[6] APM ensures the machine operations are tightly controlled only to satisfy a realistic demand, ensuring minimal wear and tear of the asset, which in turn reduces operational costs.

Predictive maintenance (PdM)

PdM techniques are designed to help determine the condition of in-service equipment to predict when maintenance is required. This approach can mean cost savings over routine or time-based preventive maintenance, because tasks are performed only when warranted.

Figure 3. Sample product opportunities for industrial

Required IoT stack devices	Industry application	
	Asset performance management (APM)	Predictive maintenance (PdM)
Sense	Electro-mechanical sensors, analog to digital converters, amplifiers	
Analyze	Microprocessors, microcontrollers, data center to perform core analyses	
Communicate	Wi-Fi, Bluetooth, Ethernet communication, near field communication (NFC), and 3G/4G cellular communication	
Security	Encryption, trusted source modules	

How to win?

Build an ecosystem to capture the big IIoT pie

The overall Industrial Internet of Things (IIoT) market is currently fragmented across sensor manufacturers, edge devices manufacturers, platform vendors, network providers, and analytics software solution providers. Semiconductor manufacturers, as outlined earlier, are dominant players and form the basic building blocks of the devices segment in the IIoT solution stack. The advent of advanced analytics and connectivity has extended the IIoT solution stack from devices to platform, gateways, and application software. By 2020, the electronics content market for manufacturing and energy is expected to reach $76 billion. Finally, services which include consulting, implementation, and operations are expected to reach $164 billion.[7] Many companies are already recognizing and acting on initiatives. Semiconductor companies can capture a greater portion of the IIoT pie by forming an ecosystem with the partners who provide different components of the ecosystem to develop an end-to-end solution. To make the ecosystem sustainable, semiconductor companies should understand and nurture the ecosystem partners to enable their growth.

Develop platform and analytics alliances

Besides building a complete ecosystem, semiconductor companies could also forge alliances with various platform makers and analytics software providers.

IIoT platform standards are beginnning to form based on open-source architectures. This benefit allows software developers to develop applications on top of the platform to perform a multitude of operations.[8] It also allows hardware/sensor manufacturers to connect to the platform with minimal effort. Thus, semiconductor companies should forge alliances with platform providers to create devices that can easily integrate with the third-party platform. A recent partnership between GE Digital, Nokia, and Qualcomm was forged to create devices that will allow companies to control their assets using LTE communication without requiring a licensed spectrum. GE Digital allows integration to Predix, Nokia is the base station infrastructure, and Qualcomm provides the wireless technology and chips. Together, semiconductor companies and platform providers can also help establish the future standard of the industrial Internet. In the coming years, significant consolidation is expected in the platform space.

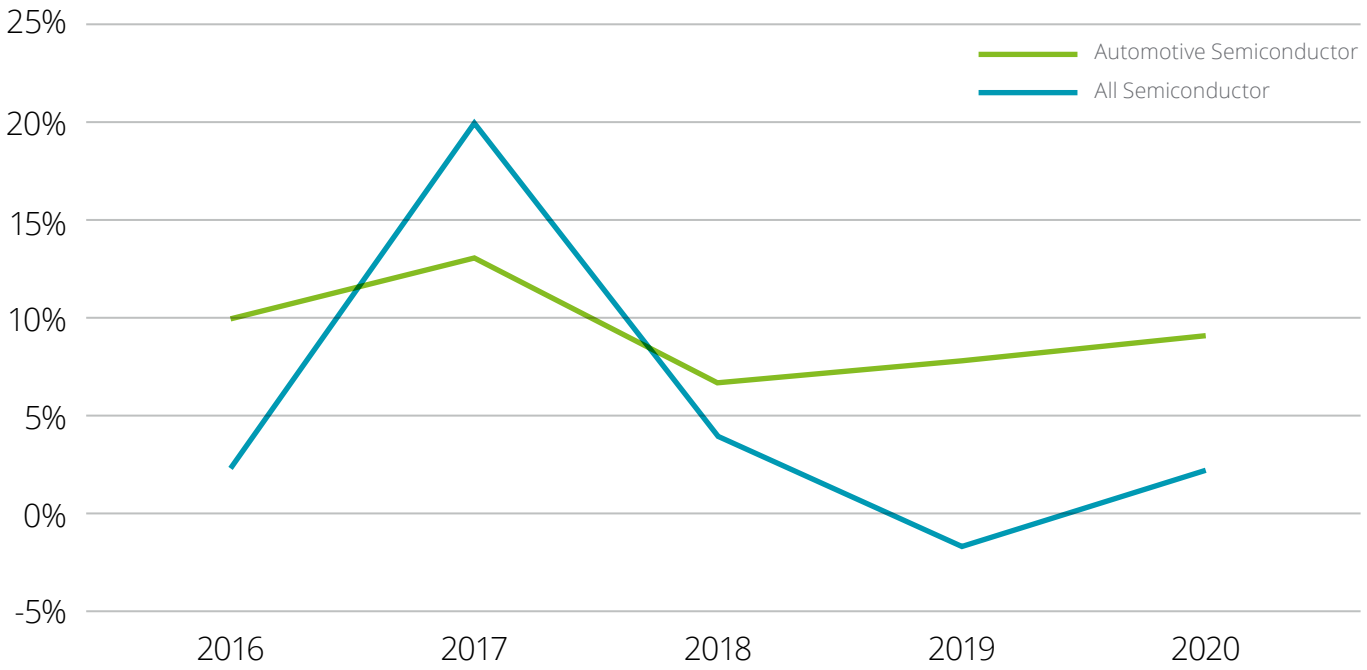
In addition, partnership with analytics software providers can provide a significant growth opportunity to semiconductor companies. The need for edge computation is expected to increase given the critical systems that are controlled in this sector, and analytics software providers can help create solutions that run natively on devices. Semiconductor companies such as Xilinx and Cavium are partnering with IIoT edge software providers, such as Foghorn, to enable their chips to seamlessly run Foghorn's solutions.

Automotive market overview

Electronic features abound in every priced model

From 2001 to 2015, automotive semiconductor revenue grew from $10 billion to $30 billion. This semiconductor segment is expected to grow to $47 billion in 2020 at a CAGR of 9.2 percent.[9] The growth rate is above average and similar to the opportunities in the industrial market.This is driven by rising electronic content in cars and the spread of electronic features from premium models to lower-priced, high-volume models.[10] Out of this spending, $10.5 billion is attributed to IoT applications.[11]

Figure 4. YoY revenue growth of automotive semiconductor vs. all semiconductor



Source: Gartner

IoT is going to change our driving experiences

Electronic content is rising in the devices and solutions that enable asset or fleet performance management, connected vehicle applications, and autonomous driving applications. Imagine a car that sends an alert to your cell phone to not only schedule maintenance, but also ensure the parts required for the repair are at the dealer before you arrive. Imagine a car that can navigate a busy freeway on its own without you having to touch the pedals. And vehicles without Wi-Fi? They'll likely be unheard of as a new generation of young drivers take the wheel. All of these advances are digitally enabled. Now, take it a step further. The systems created by these electronics are also enabling new business models and service offerings such as on-demand car solutions, insurance-as-a-service, and car-to-home integration.

These IoT applications and new business models require understanding of the insights from the vehicle's past, present, and future states. The availability of the expanded big data applications helps enable automotive IoT to grow beyond the classical automotive telematics solution and into these data-rich models that can fundamentally change driving for the better, with fewer breakdowns, fewer stranded people, less room for human error, and hopefully safer roads with fewer accidents.

The main applications are within the vehicle itself

Autonomous driving

Although still in its early stages and slowly increasing, the promise is significant; ranging from fewer accidents to less traffic, to an increase in operational efficiency. Autonomous vehicles present opportunities for semiconductor companies to provide solutions that give vehicles the ability to sense, analyze, interpret, decide, take action, and communicate with other automobiles, infrastructures, businesses, people, and organizations. The solution includes hardware, software, and data communications efforts listed in figure 5. For example, more than 25 sensors per car are required for a car to recognize its surroundings.[12]

Infotainment systems

Consumers want to be connected in a digital world. At the center of this application is the infotainment unit, where drivers can access real-time vehicle data, answer calls, play music, listen to audio books, and access GPS or navigation data. Connection to the web or cloud is generally done by tethering the driver's smartphone to the infotainment or by including cellular modules as a factory option. In both cases, semiconductor providers stand to benefit, as the number of built-in or tethered cellular communication modules is projected to increase from 6.9 million per year in 2015 to 61 million per year in 2020.[13]

Asset performance management (APM) and predictive maintenance (PdM)

APM and PdM are similar in both concept and business benefit to APM and PdM in the industrial sector. In the context of automotive, APM is more likely to serve enterprise customers with large fleets of vehicles, like delivery trucks. However, PdM for both enterprise customers and consumer vehicles would work in a similar way.

Figure 5. Sample product opportunities for automotive

Required IoT stack devices	Industry application		
	Autonomous driving	**Infotainment systems**	**Asset performance management (APM)**
Sense	Camera, radar, lidar, ultrasonic sensors	Accelerometer, gyroscope, oil/fuel, oxygen, pressure, temperature, electrical/current, GPS, camera	
Analyze	APM components + GPUs and UI components		Embedded processors for sensor fusion
Communicate	Ethernet (in-vehicle), wired/wireless LAN, DSRC, cellular	Ethernet (in-vehicle), wired/wireless LAN, Bluetooth, DSRC, cellular	Ethernet (in-vehicle), cellular, Wi-Fi
Security	Encryption, trusted platform module		

How to win?

Make sure your bases are covered

Semiconductor companies need to understand the potential challenges in the automotive IoT market to develop an effective product and go-to-market strategy. There are three main challenges in entering the automotive IoT market: 1) product life cycle, 2) safety requirements, and 3) public perception and regulations concerning autonomous vehicles.

The first challenge concerns the long product development cycles in the automotive industry due to the significant capital required to design and produce a vehicle as well as time to ensure product quality and safety standards are met. Semiconductor companies need to assess the time and investment risks in producing devices for automotive customers. To mitigate these risks, work closely with automotive customers during the product planning and design process.

The second challenge involves device quality, reliability, and security. Solving this challenge requires that companies: first, understand automotive-grade product requirements, and second, design devices with encryption and trusted platform solutions that meet the cybersecurity requirements.

Finally, semiconductor companies can mitigate public and regulator concerns by addressing them up front and working together to shape policy.

Explore providing integrated systems

Semiconductor companies also have opportunities in the automotive IoT market beyond supplying electronic components. One market segment adjacent to components is the electronic subsystems, such as an integrated system. This segment is expected to reach $110 billion by 2020, which is roughly three times the forecasted semiconductor device TAM.[14] Most semiconductor companies have included demo and prototyping boards in their go-to-market product mix. Therefore, with the right investment in system design capabilities, semiconductor companies may be able to provide a more complete electronics automotive system solution, which ultimately can increase their automotive revenue base.

Bulk up on consulting capabilities

Another possible route for increasing revenue is through consulting services and implementation services, which provide $17 billion in opportunities.[15] These market segments include IoT business strategy development and electronic system design usually for highly customized applications for customers who are traditionally not involved in end-product electronic design. To access these segments, semiconductor companies should focus on developing solutions or platforms for the commonly used end applications in the segment of interest. In addition, they'll need to leverage and enable third-party system integrators with skills to implement highly customized solutions. These two activities ensure and accelerate adoption of solutions in the market.

Partner on managed services

There's $28 billion of opportunity in managed services. However, this area is traditionally not closely related to semiconductor companies' core capabilities. There are two ways to access this segment: 1) Build your own cloud platform applications or 2) partner with existing vendors. With the first method requiring time and expertise to build assets and customer credibility for cloud platform, it may be advisable to pursue this opportunity through the second method. Finally, connectivity services or data plan is another possible segment valued at $12 billion. However, this requires high CapEx spending for infrastructure building, and semiconductor companies will likely face headwinds from existing telecom providers. It may be best accessed through partnership with existing carriers.[16]

Smart city market overview

Making life better for citizens while operating more efficiently

City dwellers are expected to make up roughly two-thirds of the world's population by 2050.[17] Smart city solutions have enormous potential to improve the lives of their citizens, making transportation easier, reducing waste and pollution on a massive scale, lowering energy consumption, and protecting against threats. Smart city solutions are made up of electronic and software systems that enable metropolitan assets to be more aware and react to their environment. Typical applications center on city management, building management, energy, infrastructure, governance, and public services.

The endpoint hardware spending for smart cities was $289 billion in 2016, and it is projected to grow to $463 billion by 2020 at a CAGR of 12.7 percent.[18] Semiconductor device sales for smart cities were $613 million in 2016 and are projected to grow to $1.2 billion by 2020.[19] The growth is mainly driven by the need for increased connectivity, improved infrastructure, and optimized energy consumption. Existing smart city applications range from highly customized niche solutions, like countering a specific climate threat to the area, to those that are common and of high interest by many cities, like smarter parking.

Figure 6. Sample product opportunities for smart cities

Required IoT stack devices	Industry application		
	Smart building	Smart parking	Smart grid
Sense	Metering and power quality sensors, electrical measurement sensors, non-electrical smart grid sensors, HVAC (heating, ventilation, and air conditioning) sensors, energy conservation sensors	Vehicle detector sensor	Smart grid sensor (including a transducer, a microcomputer, a transceiver, and a power source)
Analyze	Cloud-based building analytics that leverage artificial intelligence and machine learning, dashboards reporting system	Cloud-based analytics, intelligent parking management software	Central computer to process and analyze data and send commands
Communicate	Ethernet, other wired (USB, RS232, RS485, LonWorks, DALI), LAN (Zigbee/6LoPAN), Wi-Fi, Bluetooth, powerline, sub-GHz		
Security	Strict controls between IT system and building/parking system networks, encryption-secure coding practices to sanitize input and prevent remote execution of commands		

Major applications for smart cities? Think efficiency

Smart parking

It is estimated that at any given time, up to 30 percent of all cars in the city are looking for a parking space.[20] That wastes a lot of fuel. Smart parking systems aim to take the stress out of finding parking for drivers while reducing traffic for cities by getting cars to their destination faster. And it does so by giving individuals real-time information on available parking spots, helping to save time and reduce carbon output.[21] Such systems work by using sensor-enabled devices that show the location and number of available spaces when requested by the drivers. Coupled with RFID devices installed in the car for vehicle authentication, such a system could include reservations, parking structure access control, payment systems, and dynamic pricing capability allowing cities to offer new services to increase their revenue base.

Smart buildings

Worldwide, buildings consume 42 percent of all electricity, up to half of which is wasted. Energy costs alone represent about 30 percent of an office building's total operating costs. Smart buildings use sensors to capture energy use data that's analyzed to detect potential issues, predict upcoming maintenance, and enable optimization of a building's energy systems.[22] The application uses IoT-enabled devices that collect and send consumption data to advanced descriptive and prescriptive analytics systems.

It is estimated that the building or facilities automation electronic content market will grow to $18 billion by 2020 at a CAGR of 32 percent,[23] while connectivity services for this application are estimated to be $543 million for the same time period.[24] There's plenty of IoT opportunity for semiconductor companies.

Smart grid

People don't like to lose power. It not only creates inconvenience, but also hurts a city's economy. Cities can't have their grids down for long. Smart grid solutions enhance the electric grid with modern digital technology, such as sensing and measurement, integrated and automated communication networks, and an advanced data analytics platform. These applications allow for two-way communication between the utility and its customers. Smart grid can achieve more efficient transmission of electricity, faster power restoration after disruption, reduction in operations and management costs for utilities, reduction in peak demand, improved security, and increased integration of large-scale renewable energy systems. Smart meter solutions alone are expected to reach $755 million by 2020.[25]

In addition, cities like Borrego Springs, California, are incorporating renewable energy micro-grids, which reduce greenhouse gas emissions and, because they function independently, don't go down when the larger, traditional grid fails.[26]

How to win?

Help governments find a path to IoT

To gain competitive advantage, semiconductor companies should provide more than just components, including more comprehensive, integrated solutions through core differentiating capabilities or outside partnerships. Such a structure could not only result in a higher chance of adoption by cities, but also capture more revenue for semiconductor companies from the smart city market.

Build an ecosystem for solution

A complete smart city solution requires device manufacturers, communication hardware, connectivity protocols, cloud providers, IoT platforms, analytics and system integrators, etc.

As device manufacturers, semiconductor companies can't provide such a solution on their own. However, semiconductor companies could build and even be the control point of an ecosystem, within which they architect and help catalyze, enable, and manage the whole solution jointly developed by the partners. In many cases, semiconductor companies also need to bring the complete solutions to the city planners and jointly develop the business cases.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Health care market overview

Let's change some fundamental elements about care

Health care spending in the US is forecasted to grow from 17.8 percent to 19.9 percent of GDP in 2025.[27] US health care IT spending will reach $137 billion by 2021 at a CAGR of 12.5 percent.[28] This figure comprises $4 billion and $14 billion of electronic content spending in 2020 by health care providers and health or fitness consumers respectively, with a total of $817 million from semiconductor devices.[29, 30]

Health care IoT growth is primarily driven by remote health monitoring, workflow optimization, and integration with electronic medical records (EMRs). Insurers, as payers, and government, as regulators, are among key stakeholders in the success of health care IoT efforts to improve aggregate health outcomes and lower health care expenditure. Technology will play a key role in how fast this industry will accomplish its goals and bring about system-wide change.

Integrating IoT with electronic medical records provides a path

IoT can allow for better population health management solutions and better strategies for chronic disease care, which is a significant cost driver for the industry. When real-time collection of health data integrates with EMRs, providers can gain higher efficiencies and better outcomes at a lower cost. How does it work? Such systems collect patient-generated data, populate the data in the EMR, and apply analytics to find a data-driven, preventive treatment strategy for chronic diseases. Providers can see trends they may not have identified on their own and adjust an individual's care for the better. Healthier patients generally mean less burden on the system and lower costs.

EMRs have gone from an adoption rate of 9.4 percent in 2008 to 84 percent in 2015 among non-federal acute care hospitals, while certified ones reached 96 percent from 72 percent.[31] From the perspective of health care providers, leveraging IoT integration with EMRs is an important next step to address rising operating expense and margin pressures. Expect IoT to play a central role to opening new avenues to data in the near future—better patient outcomes are the end goal.

Major IoT applications in health care for both patient and provider

Remote health monitoring

Access to more information outside a doctor's office can open windows of insight that providers haven't had before. Used appropriately, remote health monitoring or home health monitoring can really make a difference in helping people manage chronic diseases for the better. How do they work? Remote health monitoring devices are fitted with sensors that track health indicators. They carry communication modules to notify health care providers when there are changes in a patient's vital functions. It is part of a system that enables seamless integration between data-generating medical devices to analytic platforms with the aim of lowering cost and improving outcomes in disease management. Chronic diabetes and heart disease conditions both yield themselves to this type of solution very well. Getting these diseases under control carries a high value proposition as the device sensors are apt to prevent crisis situations, keep people healthier, and lower the cost of treatment. There will likely be high market demand for remote health monitoring in the near future.

Workflow optimization

Workflow optimization devices are typically lower risk investments because ithey are nonclinical IoT applications and do not require FDA approval. Compared to other health care products, they have a relatively fast go-to-market time frame as a result. There are a variety of ways health care providers can implement these new devices. For example, RFID technology, or other wireless standards, on wrist bands and badges can optimize workflow by providing a smart and connected system between patients, providers, and medical assets. Workflow optimization devices can automatically detect and alert a provider of cleanliness using hygiene monitoring systems. Providers can also keep better track of medical tools and machines as sensors can allow real-time location and tracking services of the tools used in patient treatment. Want to know where all the heart monitors are? This IoT application allows for easy search and access.

Finally, hospitals largely depend on machines to do their work and manage patient care. When those machines go down, it can create a lot of havoc to the workflow. The same APM and PdM IoT applications used in manufacturing can benefit workflow optimization in health care, ultimately improving operational efficiency and lowering costs.

Figure 7. Sample product opportunities for health care

Required IoT stack devices	Industry application	
	Remote health monitoring	Workflow optimization
Sense	Temperature sensor, pulse oximeters, pulse/blood pressure, MEMS-based pressure sensor, weight scales, glucose meters, electrocardiogram, ultrasound scanning, MRI, position emission tomography (PET), digital stethoscopes; MEMS	Hygiene sensor, location tracker, CMOF sensor, RFID
Analyze	GPU – MRI, scanning, CPU, FPGA	
Communicate	Wireless (ANT +Bluetooth, ZigBee, Near field communication, etc.), Wi-Fi, WAN, LAN, BAN (body area network), Bluetooth, cellular, edge computing	Wireless LAN, Bluetooth, cellular, Ethernet
Security	Pre-silicon and post-silicon verification, secure storage, secure processor, secure IPs, trusted platform (TPM), encryption	

How to win?

Help facilitate a sector that's redefining care

The smart health care market presents growth opportunities for semiconductor companies on both the consumer and professional services sides. Consumer services, like remote health monitoring and fitness trackers, has the highest projected growth of $10.2 billion in 2020 at a CAGR of 41.5 percent.[32] Forecasted with a growth rate of approximately 24 percent, professional IoT services for health care providers is another promising new segment that semiconductor companies can capture additional revenue from. Such professional IoT services, including consulting, implementation, and operation services, would grow to an $18.2 billion market by 2020, with operation services having the largest opportunity at $8.4 billion.[33]

Adapt for longer life cycles with higher margin

There are a variety of factors to consider when entering the health care IoT market, including: the complexity of the health care ecosystem; compliance with personal health information (PHI) standards and government regulations. Determining which party is going to bear the cost of the device and developing a common standard for connected medical devices are also critical issues for semiconductor companies to consider. Although products in the health care space typically have high margins, semiconductor companies' product planners also need to account for the long product life cycle.

Partner to develop common standards

To mitigate the factors above, semiconductor companies should take the opportunity to become or partner to be the control point of the evolving health care IoT ecosystem, including medical device manufacturers, health care providers, insurers, and regulators. The participants can work together to develop a common standard for sustainable future growth by addressing key stakeholder requirements.

Make sure to get reliability and security right

It's a mission-critical affair for health care. On the device level, semiconductor providers need to address reliability and security. The devices should be designed to minimize the chance for malfunction and ensure that data generated from sensors are accessible only to the authorized parties. For reliability, perform pre-silicon and post-silicon verification in place as well as an accurate estimate of the product mean time to failure. To achieve the health care security requirements, semiconductor companies should provide, or work with partners to provide, embedded security features in storage, processors, and IPs. Also, secure storage and secure lock are needed to ensure users cannot change device functionality or pull data out. It is important that semiconductor companies work with IP vendors to ensure security features and risks at all levels are properly addressed.


Kitchen
Smart Home
Room Lighting
Off
On
Alarm system
Disarmed
Video Security
cam 1
cam 2
cam 3
Room Temperature
Living room
Bedroom
Nursery
Bathroom
Smart Home
Room Lighting
Alarm system
Video Security
Room Temperature

Consumer market overview

Chores be gone, IoT makes life easier, more entertaining

Consumer electronics accounted for $36 billion in semiconductor revenue in 2015, and it is forecasted to grow to $45 billion by 2020 at a CAGR of 6.4 percent.[34] From an IoT perspective, the semiconductor revenue amounts to $7.8 billion today, but it is expected to grow to $13.1 billion by 2020.[35] It's worth noting that a majority of the growth accrues from positive pricing pressure rather than volume growth, which is expected to be approximately 2.3 percent during the same time frame.[36] The volume growth will primarily be driven by increasing micro-components and sensors used within consumer appliances that enable devices to sense and analyze their surroundings. The adoption of new devices that address new value propositions is staged to grow as well. However, the value of consumer IoT products is not just about the glitz of the gadget. The value lies in the data collected and how this data makes life easier and even more entertaining.

Major applications of IoT for consumers are close to home

Smart home

Current smart home applications can broadly be divided into two types of applications. The first set of applications can be classified as foreground applications and contain those that are entertainment-based and sustain high user engagement. In contrast, the second set of applications can be classified as background applications, which comprise applications that manage dull but crucial background activities that improve daily life by automating mundane tasks.[37]

Foreground applications are primarily home media and entertainment devices. Devices such as virtual personal assistant (VPA)-enabled wireless speakers that allow users to interact with their home entertainment systems and provide a gateway to the Internet will likely be a future driver of semiconductor consumption. Traditional devices such as game consoles, smart TVs, and set-top boxes—all of which are now becoming smart and Internet connected—have already experienced broader adoption and will likely continue to be a large market.

As gaming technology moves ahead to incorporate new devices, such as motion detectors or body sensors, to facilitate gamer interaction and improve gaming experience, these entertainment devices are likely to see wider adoption.

As stated, background applications focus on making the home more comfortable and secure. Consumers can control lights, heating, and security systems from their smartphones—and even unlock doors. Appliances can send notifications or show you what's in your refrigerator from afar. Landscape systems can measure plant moisture and water only when it's necessary. Home comfort applications work on an ecosystem of connected sensors and household appliances, and they currently operate on a rule-based system. As these applications shift toward true automation through learning the household occupant's behavior, the computational needs of the ecosystem are likely to increase semiconductor consumption.

Wearables

Wearables provide consumers with devices that include a host of cloud-connected applications. Similar to smart home applications, wearable applications can also be broken down into two categories. The first is applications that provide immersive experiences and the ability to communicate. Applications powered by devices such as smart watches, head-mounted displays (HMDs), and Bluetooth headsets fall into this category. The second is passive applications that mostly deal with sensing body motion and signals, backed by devices such as sports watches, wristbands, and fitness monitors.

The large growth market, both from a device perspective and a semiconductor perspective, will likely be driven by the first category. Given their interactive and computing-heavy nature, these applications would require devices with immense capability to compute and communicate, thus driving the number of embedded semiconductor components per device.

The second category of wearables can be considered matured, by comparison, and may offer limited growth opportunity for semiconductor companies as they primarily use simple sensor and memory and communicate components. However, they do present a potential source of additional revenue as consumers seem willing to pay for health- and fitness-related applications. Application development would be key to taking advantage of these wearables.

Figure 8. Sample product opportunities for consumer

Required IoT stack devices	Industry application	
	Smart home	Wearables
Sense	Image sensor, chemical sensor, pressure sensor, temperature sensor, MEMS microphone	Image sensor, optical sensor, magnetometer, gyroscope, accelerometer
Analyze	Embedded processors for sensor fusion	Microprocessor (in device), GPU/microprocessor (required in wearable compatible gaming systems)
Communicate	Wi-Fi, Zigbee, Bluetooth, Ethernet communication	Cellular, Wi-Fi, Zigbee, Bluetooth
Security	Encryption, trusted source modules	

How to win?

Expand into subsystems and application development

The consumer IoT market is in a very early adoption cycle, and it is a market where use cases and value propositions are gradually being developed. Currently semiconductor and electronics manufacturers are expected to capture $195 billion, compared to $13.1 billion for a pure component play. On top of that, application service is expected to reach $26 billion.[38]

However, companies can still position themselves to benefit not only from component sales in the devices that power these ecosystems, but also from a strategy that would provide larger electronic subsystems. Depending on their competencies, semiconductor companies can choose to develop either generic solutions, which empower a large volume of devices with interoperability and security for various ecosystems, or specific solutions for blockbuster devices.

Focus on interoperability

Consumers today are often overwhelmed with the number of available products and the difficulty in integrating products to work together as part of a single ecosystem. Interoperability is another major concern expressed by consumers, and many companies are trying to address this issue by creating their own alliances and platforms. Semiconductor companies could benefit in aligning themselves with these partners to ensure that their products meet the end user's interoperability and standardization requirements. For example, Qualcomm partnered with Google for Android Things OS, and with Amazon Web Services for integration.[39]

Lastly, given consumers' preference to adopt a single app or device to interact with their IoT ecosystems, there will likely be a few blockbuster products that will function as IoT platforms in the consumer space.[40] Given the need for high-performance computing and communication, semiconductor companies can partner with device manufacturers in this space to develop customized hardware components as well as architectures for these platforms. While this might mean a longer product and investment cycle for semiconductor companies, it could also lead them to commanding higher margins for their product with a possibility of capturing a larger portion of the electronic content in these devices.

Simply put, build an IoT ecosystem and digital platform

The IoT electronics content spending is projected to reach $572 billion,[41] in 2020, of which $34 billion[42] is from semiconductor devices. However, the IoT market is currently highly fragmented and covers broad end applications, which makes it impossible for a single company to provide end-to-end solutions. The nature of the IoT market calls for an ecosystem of companies that share a vision and have complementary assets and skills. Semiconductor companies are well positioned to forge such an ecosystem and even be the control point of the ecosystem, as they architect and help catalyze, enable, and manage the whole solution jointly developed by the ecosystem partners. Semiconductor companies also should build an integrated digital sales platform, which will bring the ecosystem partners together to jointly sell to a broad and fragmented market. Finally, it takes time to realize the financial benefits of going into the IoT market, so it's advisable to measure success KPIs similar to a start-up.

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Appendix

Additional information on how the size of each market was derived is available upon request.

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