EQUITY RESEARCH

August 15, 2016

Internet of Things (IoT)… Big Brother Is Here

$1.4 Trillion Market

The Takeaway: We are publishing our 2016 Internet of Things (IoT) report, which provides a deep dive into a new and growing concept. IoT is a network of physical devices, vehicles, buildings, and other embedded electronics that _**allow for material improvements in visibility/tracking/efficiency/safety**_ due to the gathering of robust amounts of data. Overall, we take a look at each segment and provide our high-level thoughts on (1) the first markets to adopt IoT technology, and (2) the verticals where we think IoT will be deployed first. _Net net: we believe the growing concept will primarily benefit companies with robust software platforms and component/end-points that become increasingly complex on smaller form factors (miniaturization)._

Key winners (large cap): 1) Cisco (Jasper) – while a small portion of revenue, Jasper was acquired for $1.4B (we think ~10x sales) and is a cloud-based IoT software service platform. **2) INTC –** generates more than $2.5B of revenues from IoT segment, which we think will sustain "double-digit" growth going forward. INTC benefits from leveraging its IP and providing a host of IoT-centric solutions, ranging from entry level to high performance.

Key winners (SMID cap): Impinj – end-to-end solution provider (end-points RFID chips, connectivity, and software). Notably, ~66% of revenue comes from end-points, ~33% from connectivity (readers), and 1% is software. **Synopsys –** while ARM (acquired by Softbank) was the leading player in semiconductor IP, Synopsys is second with ~15% of revenue tied to IP (benefiting from complex chip design, miniaturization). **Connector/sensor players (APH, TEL, & ST):** should all benefit from IoT as demand for sensors (to sense physical phenomena like temperature, pressure, humidity, etc.) and connectors (to transmit the data) will both inflect higher, especially across verticals like automotive & industrial.

Top-5 trends

1. **Software platform & design:** We think the software platform is the most-attractive segment within the broad topic of IoT, as cloud-based software platforms allow companies to obtain real-time visibility and monitoring. For the design side, we think companies that provide software to create increasingly complex chips (miniaturization) will also benefit from IoT growth. Specifically, while it will be difficult to predict the percentage of chips that are being designed for IoT solutions, we think the designers will benefit from increased R&D spend on chip design.

2. **Components/end-points:** Beyond the IoT platform players, we note that component companies (end-point suppliers) should also see robust growth. From an end-market perspective, we are most bullish on end-points that address automotive, consumer, industrial, and energy while we take a cautious stance on general trackers for health and fitness. Specifically, we think smaller components (chips and sensors) will be the primary beneficiaries from the rapid growth of IoT products.

3. **Security & tracking:** Once information becomes free flowing, companies and consumers will want to keep their information secure and track devices as well. This becomes a broad topic as it includes personal information, secure tracking of objects, and IoT products used to manage access.

4. **Data analytics:** Once data is being transmitted securely, analytics would represent the next logical step of the IoT story. Information can be used to (1) help predict product failure, (2) track detailed customer patterns, and (3) anticipate human behavior.

5. **Long-term data center and networking pressure:** Assuming the proliferation of IoT devices occurs, we think data centers will need to be updated as more information is transferred at rapid rates (long-term effect). Specifically, we think this would benefit companies exposed to data center services, switches, and even line cards as well.

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Industry overview

What is IoT?

IoT is a network of physical objects that contain embedded software, sensors, and IP technology to enable them to interact with and gather data on their environment. The data collected from this process are then transmitted over the internet and can be analyzed to improve both cost and operational efficiency.

Exhibit 1: IoT architecture
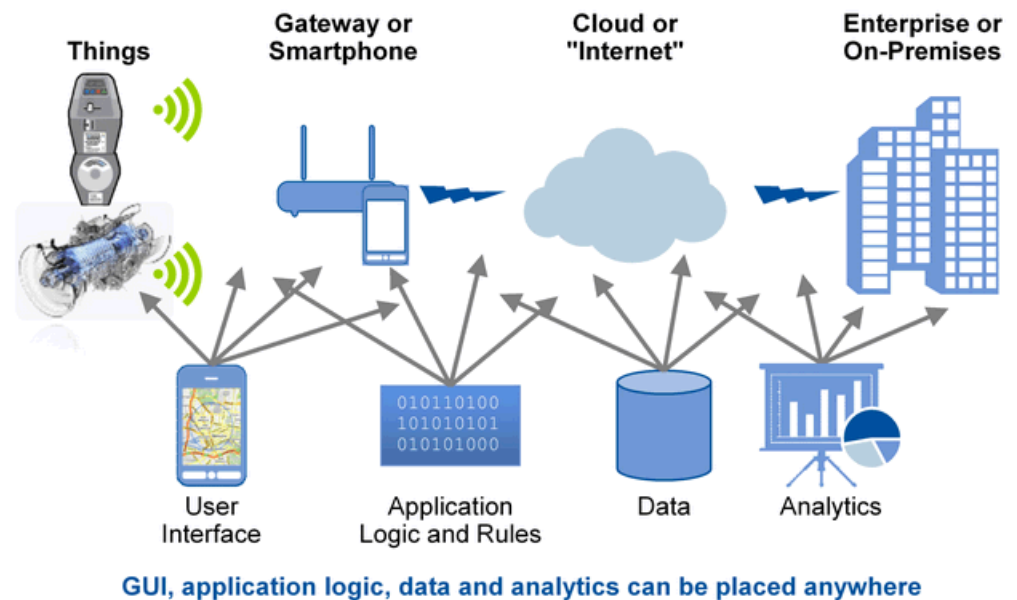
Source: Gartner Top 10 Strategic Technology Trends for 2016: Internet of Things Architecture and Platforms

One of the goals of IoT is to help integrate two segments: Machine-to-machine (M2M) communication services and operational technology. M2M communication services link connected devices to a central system autonomously, without the need for human interaction, while operational technology monitors and controls the devices (enterprises or end-users).

Exhibit 2: IOT platform architecture
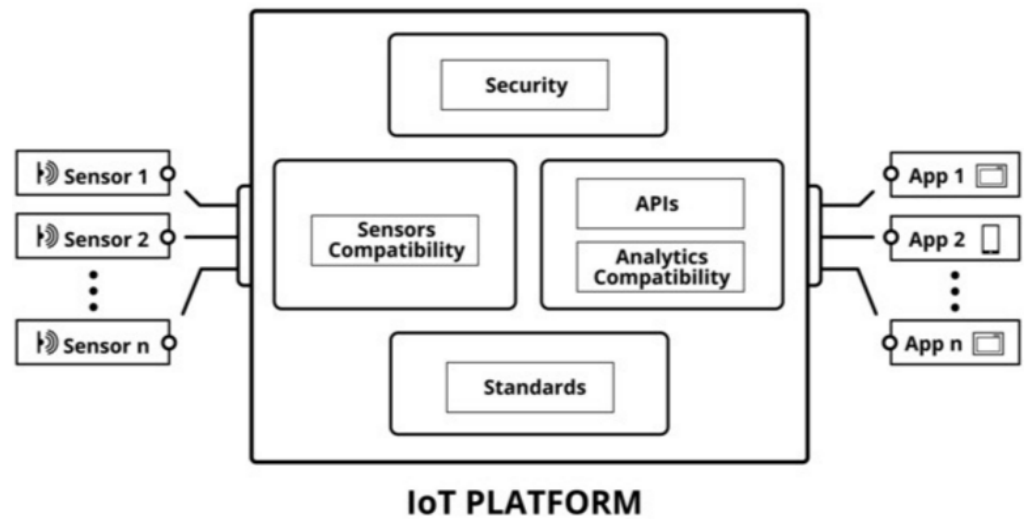
Source: Networkworld, RBC Capital Markets

The IoT platform is composed of six layers. At one end are the hardware components, which include the chips and sensors used to make IoT devices. On the other end is the cloud where all the data coming from the IoT devices are stored and processed. The layers in-between help support the communication across the two ends and across the devices through hardware equipment and software. Security, although not listed as a layer, is embedded into each layer, as it is critical to the IoT ecosystem. Multiple companies cover different layers of this stack with some covering more than one.

Exhibit 3: Different layers within the IoT platform
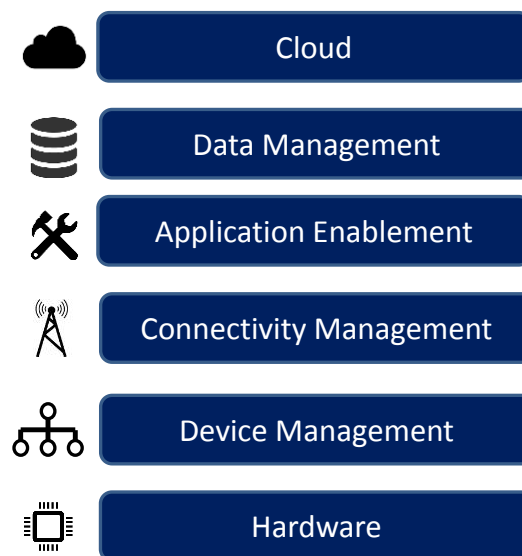
Source: HIS, RBC Capital Markets

Description of different layers in the overall IoT platform stack:

Cloud: With billions of devices expected to be connected by 2020, the amount of data generated would be enormous. Companies cannot afford to develop in-house infrastructure to process and store this data, and that is driving the need for the cloud to process and store data continuously. Cloud computing is the ideal way, in our opinion, to address the demand for deploying hundreds of application servers that are needed to support these devices.

Data management: As more and more devices become connected, they transmit large amounts of data through sensors and other machines that need to be managed and analyzed continuously across large data systems. The need to manage unstructured and geospatial data coming from the devices is becoming increasingly important. IoT calls for specific capabilities to handle diverse data constantly streaming from numerous sources. It is driving data management from the central repository toward the edge of the network, saving time, improving efficiency, and preventing the need for overwhelming databases. Managing the data at the edge also allows for performing some of the real-time analytics without the need to access the central network.

Application enablement: Application enablement is a middle-ware platform primarily needed to ease connectivity, manage devices, and data-collection activities of any IoT solution. One of the better ways to link the IoT devices to applications is through the application-enablement platform. This allows for the creation of a reliable, scalable, and cost-effective platform for the IoT solution. Application enablement also provides features such as access control and easy options for any future changes.

Connectivity management: This piece of the IoT platform stack is required to ensure the connectivity paths between the devices and servers are managed and monitored. It also provides additional tools such as real-time connectivity status, reporting, troubleshooting, and profile creation.

Device management: Device management involves managing multiple IoT devices remotely for specific functions such as reboot, factory reset, firmware download, or firmware update. Several devices can be managed at once through an application programming interface (API) on the managing agent. For example, retail products that are connected through IoT at the end consumers can all be upgraded for firmware remotely. Connectivity logs within individual devices help address specific problems remotely without the need for in-person troubleshooting.

Hardware: Hardware in the IoT platform includes the end devices that are used to collect information and transmit for analytics. The hardware specific to IoT consists primarily of sensors to collect information and RF chips to transfer information to the cloud through the network.

Key drivers of IoT

The underlying concept of IoT, connecting devices to a network, is not new, and it is prevalent in our lives. Advancements in M2M technology have enabled automated teller machines (ATMs) to communicate directly with bank servers to retrieve customer account information, automated airline kiosks to retrieve passenger information, and GPS systems to receive live traffic and weather information. However, most of the early solutions were based on a closed, private-network solution that was difficult to transfer and apply to other industries. Today's IoT-enabled solutions are primarily based on Internet Protocol (IP) based networks and standards that can be applied to the broader market. Additionally, IoT solutions typically incorporate a "feedback" loop that not only transmits data to the end-users but also receives data from the sensors to assess the health of the object and sense both the internal and external environment to operate in the most optimal way. An example is an irrigation system that measures weather and soil conditions, and then waters the plants based on the prediction of rainfall and the dryness of the soil.

Exhibit 4: IoT use case – smart irrigation system
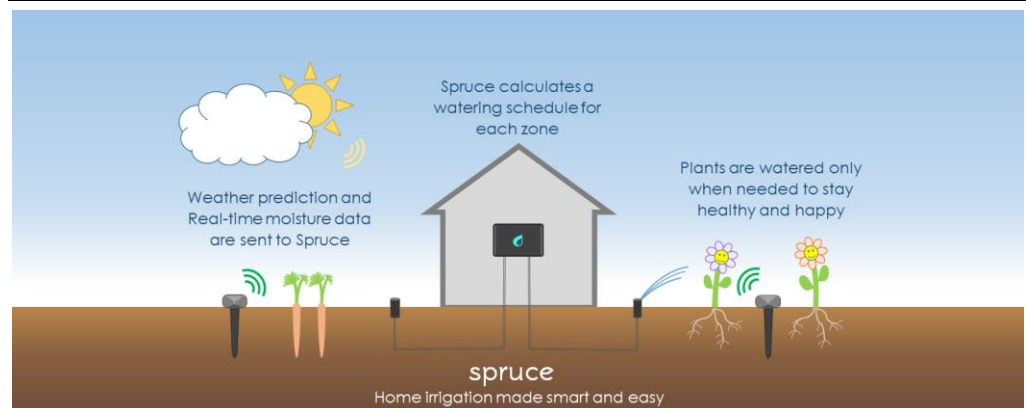
Source: Spruce

IoT has only started to pick up steam in recent years as technological advancements have paved the way for an easy and cost-friendly adoption. We describe the key trends driving IoT adoption below.

- **IP-based networking:** IP is the leading global standard for networking, with well-defined protocols, and provides a platform that can be incorporated into a wide range of devices.
- **Cost of connectivity and miniaturization of embedded technology:** The cost of sensors, wireless, and other embedded technology continues to drop and becomes less of a barrier to adoption. In addition, the size of networking and communication components continues to become smaller, which has allowed them to be incorporated into small objects. The small size, low cost, and high speed of the sensor and communication devices enable almost every object to be "smart" and connectable. Given this dynamic, complex small-form factor chips are likely to be the largest beneficiaries of IoT-related growth.
- **Mobile application platforms:** The maturation of mobile app platforms has enabled operational technology (OT) devices such as programmable logic controllers to be to be monitored and controlled from a remote device (smartphones, tablets).
- **Big data analytics:** The sensors produce large volumes of human and machine data. The rapid increases in data storage and computing power enable enterprises to collect and analyze large datasets to extract actionable insights.

- **Cloud computing:** Enterprises with limited resources can gain access to powerful back-end analytics and computing engines to process, manage, and store data via cloud computing.
- **Regulations and standards:** Regulations are becoming stricter, and new standards are forming in certain industries. New business models and use cases will develop to support the new standards, which should spur the growth of IoT.

Five key questions

1.	**What end-markets should benefit the most from IoT?**	From an end-market perspective, we are most bullish on endpoints that address automotive, consumer, industrial, and energy while we take a cautious stance on general trackers for health and fitness. We think the value proposition is the highest in automotive (safety and increase in content) while consumer would be a close second, given the ability to track spending patterns and improve day-to-day life. Overall, content proliferation will act as a "bar-bell" with smaller low-cost chips selling in high volumes and higher-end chips infiltrating large mechanical equipment, in our view.
2.	**What companies will see the largest reduction in costs?**	With the cost of smaller complex chips coming down, we think industrial- and energy-related companies will benefit first. As complex chips help predict the failure of products and recognize changes within a complex system, efficiency gains should occur in both industries.
3.	**Where will the value reside if IoT-related products accelerate?**	There are five key platforms (excluding hardware) that will likely command the most value: **(1) Cloud –** infrastructure to process and store data; **(2) Data management –** IoT devices will transmit large amounts of data through sensors and other machines that need to be managed and analyzed; **(3) Application enablement –** middle-ware platform needed to ease connectivity, manage devices, and data-collection activities of IoT solutions; **(4) Connectivity management –** ensuring the connectivity paths between the devices and servers are managed and monitored; and **(5) Device management –** device management involves managing multiple IoT devices remotely for specific functions such as reboot, factory reset, firmware download, or firmware update.
4.	**How will information be collected?**	While we think the primary value resides on the platform side of the equation, we think the secondary growth vector is within hardware/components as IoT products (particularly in smaller form factors) collect and transmit information.
5.	**Who are the major IoT players?**	IoT is a new concept; however, within our coverage framework, we think there are several companies with clear IoT benefits. **IT hardware/networking segment – Cisco (Jasper):** While a small portion of revenue, Jasper was acquired for $1.4B (we think ~10x sales) and is a cloud-based IoT Software service platform. Jasper has partnered with 27 global service provider groups, and the IoT service platform provides connectivity over cellular to more than 3,500 enterprises. **Impinj:** End-to-end solution provider—endpoints radio-frequency identification (RFID) chips, connectivity, and software. Notably, ~66% of revenue comes from endpoints, ~33% from connectivity (readers), and 1% is software. **Semiconductors – INTC:** generates ~$2.5B of revenues from the IoT segment (~5% of total), and we think this segment will sustain double-digit sales growth driven by the proliferation of its low-power, low-latency solutions for IoT devices. **Synopsys:** While ARM (acquired by Softbank) was the leading player in semiconductor IP, Synopsys is second with ~15% of revenue tied to IP. As chips become smaller (and more complex) over time, design companies such as Synopsys should see benefits. **Tech supply chain –** We expect companies like APH, TEL, and ST to benefit from electronics being deployed in the automotive vertical coupled with the continued miniaturization trend.

RBC Capital Markets industry perspective

Driving forces behind IoT: We think IoT is creating a fundamental shift in how enterprises approach their business. Organizations across all industries are seeing incremental benefits from sensor data that identify areas of both cost and operating efficiencies. In recent years, the explosion of data volumes and the number of connected devices used by consumers and enterprises have vaulted the IoT market and its ancillary markets, such as networking, as organizations have begun to invest in network infrastructure and capacity to manage the high data traffic from the sensors. We expect the IoT industry to remain prominent and grow at a more than 20% rate over the next several years.

Expanding use cases: In its early stages, a connected device was primarily used for tracking and asset management. With the technological advances, the sensors have become increasingly more powerful in a smaller form factor. These advanced sensors enable use in cases beyond simple location-based services such as home automation, connected vehicles, smart energy, service management, and factory automation, among others.

Robust growth expected for software and component companies: We believe software and component companies are best positioned to reap the benefits from a broader IoT adoption. Analytics software provides the end tool that makes sense of the massive amount of data collected from the devices, enabling companies to gain real-time visibility into their business. Additionally, we think electronic design automation (EDA) companies should see an incremental benefit by providing software that helps create complex chips with a small footprint. Beyond the software vendors, component companies that supply endpoint chips and sensors should also see robust growth as more organizations seek to gain competitive advantage by making everyday objects "smart".

End-market beneficiaries: From an end-market perspective, we are most bullish on markets that have a defined refresh cycle (automotive) or industries that can enjoy substantial cost savings from IoT (industrial, manufacturing, and energy). We highlight our expectations for key end-markets below.

Automotive: We take a more bullish stance based on the annual refresh cycle of the automotive market that makes it easier to introduce new technologies. On average, there are ~15 electronic subsystems in a connected vehicle, from the chassis to infotainment systems, which represents multiple points of integration for the components companies.

Energy & utilities: We think the energy market will see an added boost compared to expectations, driven by the added cost benefits from smart-grid/meter technology as well as tighter regulations that require participants to increase fuel economy by actively monitoring and tracking energy consumption.

Consumer: Within the consumer market, we look at two emerging segments – smart homes and wearables. We are taking a cautious stance on near-term growth opportunities for both consumer markets, supported by tepid growth for home automation/security (Google Nest), smart watches (Apple Watch, Samsung Gear), and fitness trackers (Fitbit). We also note that smartphones already offer similar functionalities as most fitness trackers. However, we note that growth prospects for smart homes may be more favourable in the long run as technology matures and the cost of the solutions decreases.

Industrial & manufacturing: Many consider IoT to be the next big catalyst in driving a new wave of industrial revolution that provides full factory automation and complete visibility into the manufacturing supply chain. Additionally, organizations can achieve product lifecycle and service lifecycle management improvements through IoT. Manufacturers can issue

relevant upgrades on their next product version by analyzing current points of failure, and organizations will be better fitted to service their products both remotely and on-site by monitoring the product health in real time and identifying any areas for concern. This should ultimately improve the customer experience from improved uptimes and timely updates.

RBC Capital Market expectations: While Gartner is suggesting total IoT market growth from 2015 to 2020E of ~20.5%, we think there is upside potential in three key segments: automotive, energy, and industrial. From an end-market basis, Gartner expects the automotive segment to grow 35% through 2020E, energy at 20%, and industrial at 19%. With a historical track record well above current forecasts, we think it is reasonable to assume that automotive could grow 38%, energy 25%, and industrial 22% from 2015 to 2020E. We are more cautious on the smart home and wearables market, and model average growth rates of 29% and 14%, respectively, versus Gartner's forecasts of 36% and 22%. This would result in a total 2015–2019E CAGR of 21.9%, which is ~140bps ahead of Gartner expectations.

Exhibit 5: RBC Capital Markets IoT market growth expectations ($ in billions, 2015–2020E)
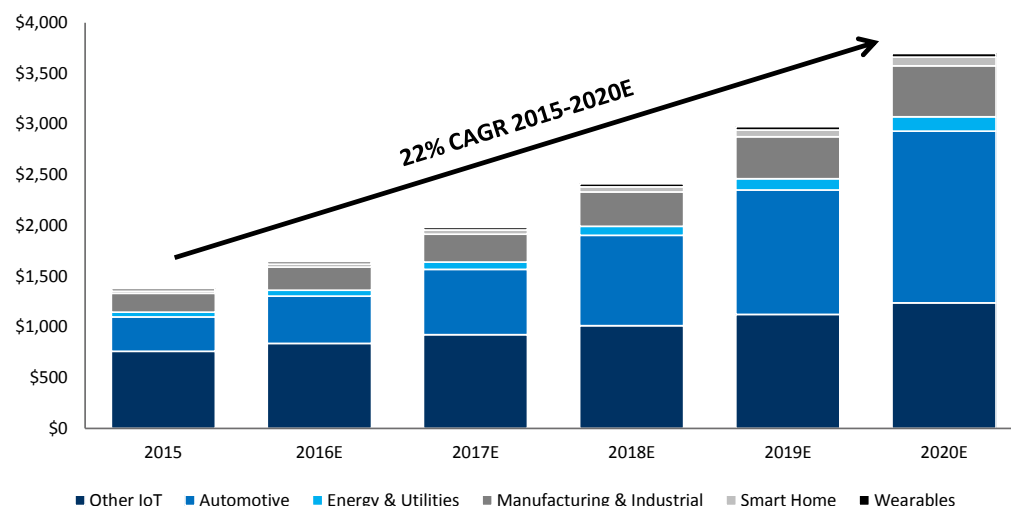
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015, by Peter Middleton et al., RBC Capital Markets estimates

From a differentiation perspective, this results in deltas to current expectations as follows:

- **Automotive:** We anticipate ~3% additional growth vs. consensus.
- **Energy:** We anticipate ~5% additional growth vs. consensus.
- **Manufacturing:** We anticipate ~3% additional growth vs. consensus.
- **Smart Home:** We anticipate growth to be 7% less vs. consensus.
- **Wearable:** We anticipate growth to be 8% less vs. consensus.

Exhibit 6: RBC Capital Markets IoT market growth differentiation ($ in billions, 2015–2020E)

	2015	2016E	2017E	2018E	2019E	2020E	CAGR 2015-2020E	Consensus	Delta
Automotive	$338.1	$466.6	$643.9	$888.6	$1,226.3	$1,692.3	38%	35%	3%
Energy & Utilities	$46.0	$57.5	$71.8	$89.8	$112.3	$140.3	25%	20%	5%
Manufacturing & Industrial	$186.1	$227.0	$277.0	$337.9	$412.2	$502.9	22%	19%	3%
Smart Home	$23.8	$30.7	$39.6	$51.1	$66.0	$85.1	29%	36%	-7%
Wearables	$19.9	$22.6	$25.8	$29.4	$33.5	$38.2	14%	22%	-8%
Other IoT	$762.1	$839.6	$924.1	$1,014.9	$1,124.3	$1,239.1	10%	10%	0%
Total	**$1,376.0**	**$1,644.1**	**$1,982.3**	**$2,411.8**	**$2,974.6**	**$3,698.0**	**21.9%**	**20%**	**1%**

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets estimates

Networking and component companies affected by IoT

Cisco Systems (Outperform, $35 price target)

Cisco has a wide range of IoT products across almost every industry vertical, leveraging relationships from its legacy products. However, as IoT becomes a mainstream technology trend affecting most industries and markets, Cisco has been aggressive in developing even software for its IoT services. Prior to its Jasper acquisition, Cisco's focus in IoT was primarily on the ruggedized gateways, connectivity for non-cellular wireless, fixed assets, and data connectivity analytics within the IoT stack. Cisco's presence in industrial, retail, automotive, transportation, and other verticals provides a gateway to offering IoT solutions to those customers, driving equipment sales, and deepening relationships.

Cisco offers IoT solutions on a number of fronts: network connectivity, applications, security, analytics, and automation.

Network: Cisco's 1000-5000 series switches, aggregation services routers (ASR) routers and Aironet access points are equipment supporting IoT applications.

Applications: Cisco's Fog applications enable its switches and routers to perform real-time control functions using IoT sensor data for functions such as asset management, energy monitoring, and smart parking.

Security: Cisco's FirePOWER series for network security and IP cameras for physical security are offerings on the equipment front and advanced malware protection services on the software front.

Analytics: Cisco's connected streaming analytics works with active data coming from the equipment sensors to detect issues and make time-sensitive decisions.

Automation: Cisco's Field Director helps reduce management complexity by delivering robust and intuitive workflow solutions.

Although Cisco is a leader in most of the IoT stack, we think the company needs to strengthen relationships further in the cellular wireless space. The addition of Jasper to its IoT efforts helps fill that gap, in our opinion.

Jasper: Acquired in March 2016, Jasper is a cloud-based software platform for IoT. It is the largest IoT software service platform in the market. It helps manage, launch, and monetize IoT services, all on a single platform. Jasper highlights that the real value of IoT is not in the devices themselves but in the services that they enable and the new, often recurring, sources of revenue that those services generate. Jasper helps businesses bring their IoT solutions to customers faster with a readily usable and scalable platform. It enables businesses with the ability to have real-time visibility and to monitor the status of their devices from any place 24/7. Since Jasper integrates platforms from carriers across the globe, businesses can expand at a much faster rate and start capitalizing on new revenue opportunities without worrying about platform compatibility. Jasper's IoT platform also includes automation, which can optimize performance on the fly, lower operational costs, and provide uninterrupted services and exceptional customer experiences.

Jasper by itself covers just one portion of the overall IoT stack that includes cloud, data management, application enablement, connectivity management, and device management, in addition to the hardware. Cisco's IoT portfolio prior to Jasper's acquisition covered most of the stack but was weaker with regard to connectivity for its customers. Now with Jasper,

Cisco provides a complete end-to-end IoT platform that enables it to support cellular management, which was missing from Cisco's IoT portfolio. Adding Jasper helps bring a predictable, recurring revenue model to Cisco, complementing its business strategy to grow in the software and services spaces.

Exhibit 7: Overall IoT stack and Jasper's focus – connectivity management
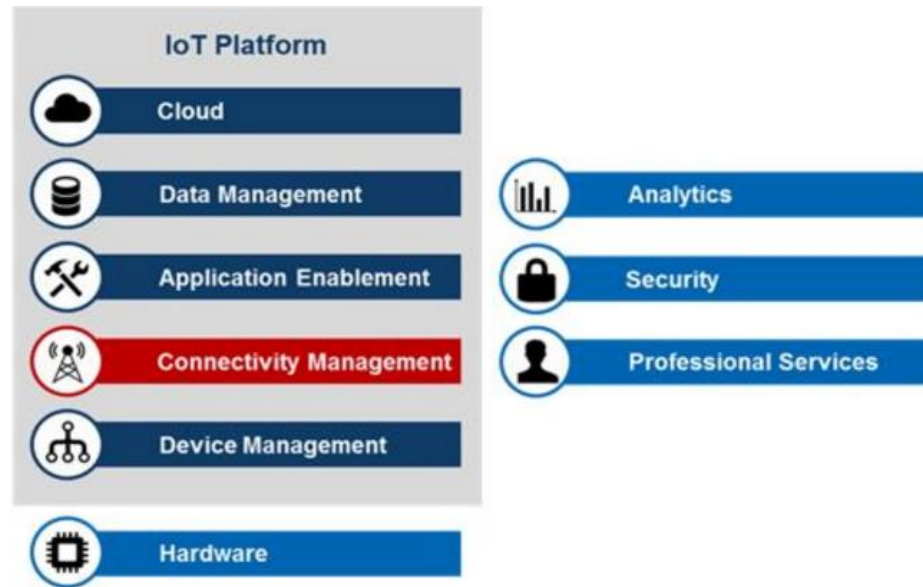
Source: IHS

Together with Cisco, Jasper now offers comprehensive end-to-end IoT solutions across a number of industry verticals, making it a preferred choice for standalone businesses and for businesses that function across multiple industry sectors, in our view.

Exhibit 8: Jasper's IoT platforms

Platform	Features
Connected Cars	• Ensure components work perfectly upfront by testing connectivity during assembly. • Prepare connected vehicles to arrive in sell-ready condition using Control Center to remotely test connectivity of built-in sensors. • Automated rules make it easy to verify battery levels, tire pressure, and overall vehicle state in transit • Drive sales at the dealership with compelling connected car experiences. • Build a profitable recurring-revenue connected cars service business for the post-sales lifetime of every vehicle.
Industrial Equipment	• Maximize uptime and increase efficiency • Reduce operational costs with real-time visibility and control • Remote maintenance with 24/7 monitoring • Allows to automatically pinpoint, resolve and prevent issues
Mobile Enterprise	• One stop shop to manage entire mobile deployment • Enables access to mobile usage data instantly • Enables automation to streamline management of mobile assets • Self-serve with easily accessible controls
Retail & Payment Solutions	• Helps keep vending machines well stocked through 24/7 visibility of inventory • Provides visibility to demand patterns to improve efficiency • Enables to check for point of Sale (POS) devices online availability and functionality including remote diagnostics • For parking meters and ATMs, enables easy monitoring for payments with automated provisioning and service activation
Security & Home Automation	• Helps increase revenue by rapidly launching new connected services such as energy management, appliance control, fire detection and home security • Helps remotely test devices and set rules for automating activation • Controls interoperability costs across connected devices and services
Transportation & Logistics	• Helps with fleet management with real time visibility of all connected mobile assets. • Helps with asset tracking and improve supply chain logistics • Minimize downtime with real-time intelligence providing drivers with up-to-date traffic and navigational data

Source: Jasper, RBC Capital Markets

Intel (Sector Perform, $36 price target)

Intel should benefit from the proliferation of IoT in two fundamental ways: (1) demand for low-power, low-latency chips as there is explosive growth for connected devices; INTC is able to leverage its IP from the entire compute ecosystem and sell IoT-catered products like Atom, Core, Xeon, Xeon PHI, and Quark; and (2) the virtuous cycle of growth within data center that should enable the next wave of cloud development driven by IoT. INTC is on track to generate ~$2.5B of revenues from its IoT segment, implying year-over-year growth of 10%. Long term, the company anticipates that this segment should sustain double-digit revenue growth.

Exhibit 9: Intel IoT group revenue ($ in millions)
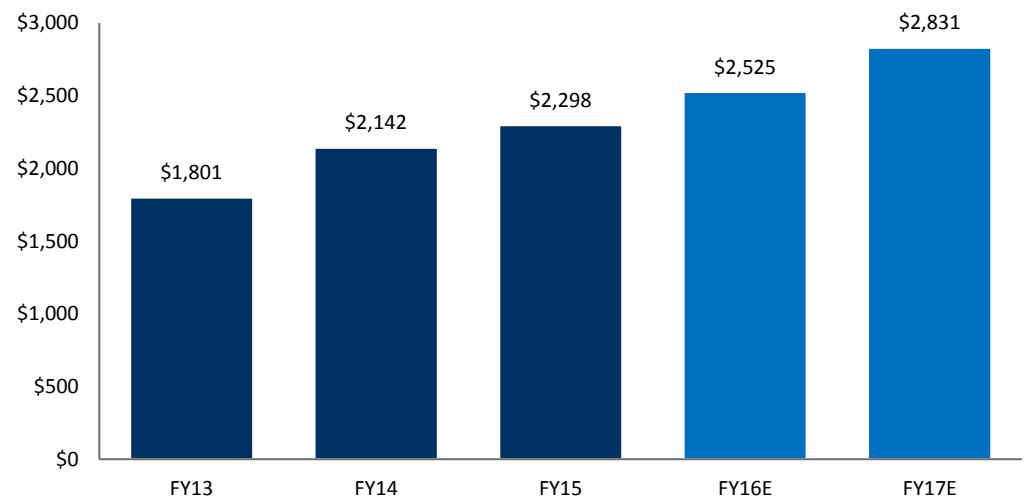
Source: Company reports, RBC Capital Markets estimates

Expanding opportunity with strong growth: We estimate INTC's internet of things group (IOTG) market opportunity is ~$15–18B, focused within five key verticals – (1) retail, where IoT-centric growth should be at a 20%+ CAGR; (2) transportation/automotive, where we estimate the fastest growth for INTC at ~30% CAGR; (3) industrial/energy is the largest portion of its serviceable available market (SAM) and should sustain 10% CAGR; (4) market & channel acceleration, which includes verticals like healthcare, gaming, printing, etc.; this bucket is pegged to sustain ~10%+ CAGR; and (5) smart home/building solutions that should grow in line to modestly below the 10% CAGR target.

Exhibit 10: Intel IoT opportunity by vertical

Source: Intel

Attractive product portfolio: An inherent and unique benefit that INTC enjoys is its ability to leverage its IP from PC and data center markets, and tailor them to IoT-use cases. INTC is able to offer a host of solutions ranging from entry-level performance chips like INTC Quark or Atom that have an average selling price (ASP) of ~$5–30 for certain markets where performance is not the primary factor to high-performance microprocessor (MPU) (INTC Xeon), where performance is more important, and INTC receives premium pricing of $100–2,000+.

Exhibit 11: Intel IoT market opportunity by product
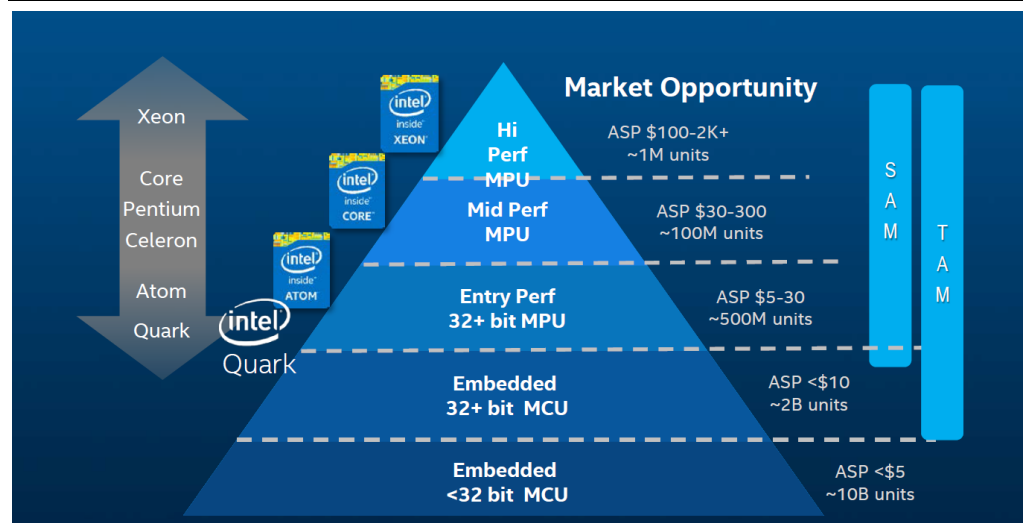

Source: Intel

Impinj (Outperform, $25 price target)

In conjunction with this report, we are initiating coverage on Impinj with an Outperform rating and $25 price target with the following highlights: (1) large market opportunity with IoT potential; (2) 25%+ sustainable long-term revenue growth; (3) clear path to mid-teens EBITDA margins; and (4) leading-edge technology with an end-to-end solution from endpoints to software.

Impinj is a RAIN RFID solutions provider that offers wireless connectivity for everyday items and delivers intelligence information to organizations and consumer applications. The company's platform comprises of software, hardware, and application interfaces that assign a unique identity to each item and enable inventory management, patient safety, asset tracking, and item authentication. Impinj's product portfolio provides a foundation for the IoT.

Recent IPO: On July 21, 2016 Impinj went public at an IPO price of $14.00 per share offering 4.8M shares and raising $60M in total proceeds. The entire offering was primary and the existing shareholders are now subject to a 180-day lock-up post IPO. The company is raising funds to 1) pay of $5M in debt and 2) the remainder for working capital and other general corporate purposes. In addition, we think the company will utilize the cash to help its sales force become focused over the next twelve months.

Impinj platform: Impinj is the only player in the market to offer a full stack of solutions from tag ICs to front-end software. Radio technology is optimized at each layer of the platform for stronger performance, versatility, and ease-of-use compared to mix-and-match systems. Importantly, the company helped co-found the RAIN Industry Alliance and the RAIN radio standard, with more than 235 patents.

Exhibit 12: Impinj platform
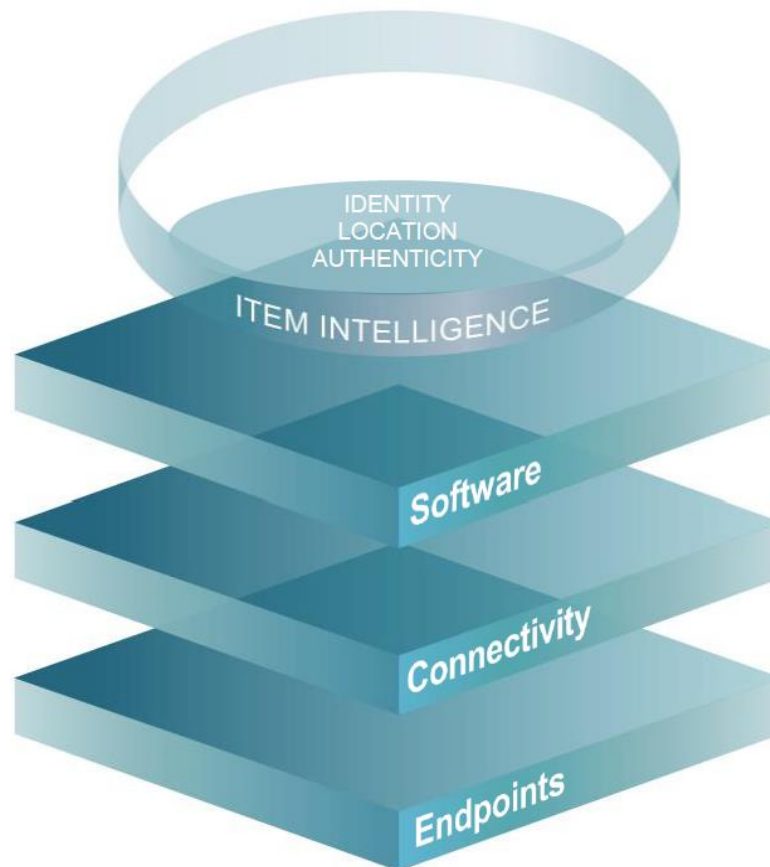
Source: Company reports

- **Endpoints (two-third of sales, ~50% GM):** Tag ICs attached or embedded into objects that provide the item's unique identity and location.
- **Connectivity (~one-third of sales, more than 60% GM):** Stationary/mobile readers or reader ICs that communicate with the endpoints (read, write, authenticate, etc.). Also includes gateways that are used to locate and track tagged items.
- **Software (less than 1% of sales, 90%+ GM):** User interface that aggregates and delivers item intelligence from the data obtained from the endpoints. The software is also used to configure, manage, and control readers and gateways.

While Impinj faces competition at each layer of the platform, it is the only vendor with a complete product portfolio:

- For example, NXP competes at the endpoints layer but does not offer connectivity or software solutions, while Zebra Technologies offers software and connectivity solutions but depends on Impinj for endpoints and reader ICs.
- With a full platform, Impinj could tap into the existing customer base for upsell/cross-sell opportunities.

We think competition could become more fierce as IoT solutions become more prevalent and more devices are being connected. The competitive dynamic will largely depend on: (1) portfolio performance, reliability, and features, (2) average selling prices, (3) development tools and APIs, and (4) integration and certification with end-user applications.

Exhibit 13: Competitive landscape

Source: RBC Capital Markets

Customers: Impinj's target market spans across multiple industries, including retail, healthcare, automotive, industrial, manufacturing, government, and financial services. To date, the company has sold over 13 billion endpoint and 1 million connectivity solutions.

Large TAM: The current TAM is estimated at ~$10 billion today and should grow at a 21%+ CAGR through 2020, fueled by rapid demand and for IoT-related solutions at the enterprise and consumer levels. Two of Impinj's large verticals (retail and healthcare) are largely underpenetrated and represent a more than $10 billion market over next five years (+39% CAGR through 2020 in retail and +17% for healthcare). Retail should drive near-term growth, while healthcare and industrial are long-term drivers, in our view.

Partners: Impinj sells tag ICs direct, primarily to inlay and tag original equipment manufacturers (OEMs) and original design manufacturers (ODMs). In 2015, sales to Avery Dennison Corporation, or Avery, Shang Yang RFID Technology Yangzhou Co. Ltd., or Shang Yang, and Smartrac NV, or Smartrac, respectively accounted for 23%, 22%, and 20% of tag IC revenue, and 16%, 15%, and 14% of total revenue. In addition, the company sells reader ICs primarily through distribution to reader OEMs and ODMs. In 2015, distributor sell-thru to its top-two reader IC partners each accounted for 23% of reader IC revenue, but neither accounted for more than 10% of total revenue. Readers and gateways are primarily sold through distribution to VARs and SIs. Finally, in 2015, Impinj had one distributor, BlueStar, Inc., that accounted for 39% of readers and gateway revenue and 10% of our total revenue, but no end customer accounted for more than 10% of total revenue.

Exhibit 14: Partners

Source: Company reports and RBC Capital Markets

Visualizing the Impinj experience

The retail experience: Currently, most retail outlets are built with standard barcode scanners. These devices reduce the speed at check out, do not provide tracking information, and cannot be recognized by readers from long ranges. If we were to replace the tag with an Impinj product, then the company receives the following benefits for only a few pennies per chip:

1) Items would no longer be "hidden" within a store, as the readers would be able to track the chip attached to the shirt, pants, shoes, or any other retail product.
2) Within a changing room, if LCD screens were installed, then the product could be recognized and immediately provide product recommendations that match the item that the customer had chosen.
3) At check out, instead of needing to scan each item, the product is placed near a reader that rings up several items at once, thereby increasing check-out speed.

The result of deploying Impinj technology is a ~10% revenue uplift for the customer (due to clear visibility of where all items of all sizes are located) and potential upsells. In addition, as products are deployed in warehouses, the system could be used to ship products, if they were not available in a specific outlet at that time.

Specific Example: In a retail store, the Impinj chip is _attached_ to the paper tag and there is no longer a bar code. The chip can then be tracked as it moves around the store given that Impinj readers are sitting on top of the ceiling, similar to a circular black security camera. When the user takes the item to a dressing room, if LCD screens are installed, the LCD screen can then recognize the chip (with all the information on the product) allowing the screen to recommend products to the customer. Finally, at check out, instead of the tags being scanned they are simply placed onto the counter where a reader collects all of the pricing information. The consumer then takes all the products and the ~1-5c chip is discarded along with the tag (consumable).

Healthcare experience: While there is risk in deploying new technologies in healthcare facilities (particularly emergency rooms), the value in tracking items within a high-pressure environment is large. As the technology is deployed into hospitals, nurses and doctors would know when to (1) replace usable items that are running low (syringes for example) and (2) would be able to track down important medical devices as they are moved from room to room (decreasing the time to service a patient in need).

Other experiences: Beyond healthcare and retail, Impinj devices could also be used in airports (bag tracking), restaurants (tracking customers to deliver food), and potentially a security device. From the security standpoint, this would allow entry (or prevent entry) due to the type of RFID chip attached to each employee's bag.

Synopsys (Outperform, $64 price target)

Synopsys has ~15% market share of the overall design IP market. This sub-sector refers to reusable designs or blocks/units; these IP pieces can be licensed to other users or used by the owner only. *The reusable designs can be used as starting points or building blocks for chip design.* Importantly, from a market-share perspective, Arm remains the leader at ~46% of total share, followed by Synopsys (14%), Imagination Technologies (9%), and Cadence Design Systems (5%).

Exhibit 15: Third-party semiconductor design IP vendors

($ in millions)	2014 Revenue	y/y Growth	Share
ARM	1,234.40	16%	46%
Synopsys	371.1	9%	14%
Imagination Technologies	237.1	7%	9%
Cadence Design Systems	125.8	0%	5%
Silicon Image	59.9	22%	2%
Ceva	50.8	4%	2%
Sonics	40.4	12%	2%
Rambus	35.7	4%	1%
eMemory Technology	33.5	22%	1%
Vivante	27.6	10%	1%
Others	466.9	-5%	17%

Source: Gartner, Market Share Analysis: Semiconductor Design Intellectual Property, Worldwide, 2014, by Ganesh Ramamoorthy

We note that the company has material exposure to interface, memory on a chip, analog, and physical IP. Importantly, when we look at the company's IP products, it offers many solutions with its DesignWare IP Portfolio including:

1) High-quality solutions for widely used wired and wireless interfaces such as universal serial bus (USB), peripheral component interconnect (PCI) express, double data rate (DDR), Ethernet, serial AT attachment (SATA), mobile industry processor interface (MIPI), high-definition multimedia interface (HDMI), and Bluetooth Smart.
2) Logic libraries and embedded memories, including static random-access memory (SRAM) and non-volatile memory.
3) Configurable processor cores and application-specific instruction-set processors (ASIPs) for embedded and deeply embedded designs.
4) IP subsystems for audio and sensor functionality that combine IP blocks and software into an integrated, pre-verified solution.
5) Security IP, which includes cryptographic cores, security protocol accelerators and co-processors, embedded security IP modules, secure boot and cryptography middleware, and content protection IP for integration into system on chips (SoCs).
6) Analog IP for analog-to-digital data conversion and audio.
7) SoC infrastructure IP including minPower datapath components, ARM® AMBA® interconnect fabric and peripherals, and verification IP.

Exhibit 16: Synopsys IoT-related IP

IP Category	Highlights
Wired Interface IP	• Supports a wide range of protocols such as USB, PCI Express, DDR, MIPI, HDMI and SATA. • Specific IP implements key power management features including multiple power rails, hibernation, USB battery charging, PCI Express L1 sub-states along with power gating techniques
Wireless Bluetooth Smart IP	• Compact IP eases integration for energy-efficient IoT SoCs • Easy integration into energy-efficient IoT SoCs • Extended battery life with low-power PHY IP operating down to below one volt supply
Security IP	• Includes IP for cryptography, security subsystems, platform security and content protection for integration into system-on-chips. • Helps prevent a wide range of evolving threats in connected devices such as theft, tampering, side channels attacks, malware and data breaches.
Analog IP	• Analog IP implements extensive low-power design techniques to reduce IP power dissipation by up to 5X. • Power dissipation is reduced in active, shut-off, and idle operations, making the analog IP ideal for power-sensitive applications and wearable devices.
Integrated sensor and controp IP subsystems	• Optimized to process data from digital and analog sensors • Provides designers with a complete, pre-verified solution that optimizes sensor functions for IoT markets. • Integrated hardware accelerators for sensor-specific functions boost performance efficiency and reduce power consumption by up to 85% compared to discrete solutions

Source: Company reports

Given the material exposure to multiple high-growth segments within semiconductor IP, we think the company has a diversified revenue stream within the sub-segment, giving the company exposure to chip miniaturization that should occur if IoT units continue to grow.

Exhibit 17: IP growth by segment — anticipate high-single-digit growth ahead

($ in millions)	2014	2015	2016E	2017E	2018E	2019E	($ in millions)	2014	2015	2016E	2017E	2018E	2019E
Microprocessor	$1,144.8	$1,331.4	$1,589.5	$1,753.4	$1,905.3	$2,055.8	Block Libraries	$20.1	$20.1	$20.2	$20.0	$20.2	$20.0
Y/Y Growth	--	*16.3%*	*19.4%*	*10.3%*	*8.7%*	*7.9%*	*Y/Y Growth*	--	*0.0%*	*0.5%*	*-1.0%*	*1.0%*	*-1.0%*
DSP	$120.1	$121.4	$123.8	$123.3	$125.5	$127.8	Controllers and Peripherals	$9.4	$9.6	$9.8	$10.0	$10.2	$10.4
Y/Y Growth	--	*1.1%*	*2.0%*	*-0.4%*	*1.8%*	*1.8%*	*Y/Y Growth*	--	*2.1%*	*2.1%*	*2.0%*	*2.0%*	*2.0%*
Total Processor IP	**1,264.90**	**1,452.80**	**1,713.30**	**1,876.70**	**2,030.80**	**2,183.60**	Graphic IP	$240.7	$263.5	$303.3	$320.7	$323.6	$333.3
Y/Y Growth	***0.00***	***14.9%***	***17.9%***	***9.5%***	***8.2%***	***7.5%***	*Y/Y Growth*	--	*9.5%*	*15.1%*	*5.7%*	*0.9%*	*3.0%*
GP Analog and Mixed Signal	$64.6	$64.9	$80.8	$86.2	$92.8	$99.3	Fixed-function	$170.3	$182.5	$198.8	$213.2	$230.2	$248.9
Y/Y Growth	--	*0.5%*	*24.5%*	*6.7%*	*7.7%*	*7.0%*	*Y/Y Growth*	--	*7.2%*	*8.9%*	*7.2%*	*8.0%*	*8.1%*
Memory Cells/Blocks	$251.1	$262.5	$276.9	$291.4	$303.7	$316.4	Subsystems	$11.0	$11.5	$11.7	$9.5	$9.8	$10.1
Y/Y Growth	--	*4.5%*	*5.5%*	*5.2%*	*4.2%*	*4.2%*	*Y/Y Growth*	--	*4.5%*	*1.7%*	*-18.8%*	*3.2%*	*3.1%*
Physical Library	$72.6	$73.5	$76.1	$76.8	$67.1	$67.9	Infrastructure IP	$59.0	$63.5	$67.8	$72.5	$77.6	$83.2
Y/Y Growth	--	*1.2%*	*3.5%*	*0.9%*	*-12.6%*	*1.2%*	*Y/Y Growth*	--	*7.6%*	*6.8%*	*6.9%*	*7.0%*	*7.2%*
Wired Interface IP	$476.8	$516.5	$571.8	$609.5	$640.0	$725.7	Miscellaneous IP	$15.0	$15.2	$16.1	$17.8	$20.1	$22.6
Y/Y Growth	--	*8.3%*	*10.7%*	*6.6%*	*5.0%*	*13.4%*	*Y/Y Growth*	--	*1.3%*	*5.9%*	*10.6%*	*12.9%*	*12.4%*
Wireless Interface IP	$28.0	$34.6	$41.5	$48.8	$58.0	$67.8	**Total Digital IP**	**525.5**	**565.9**	**627.7**	**663.7**	**691.7**	**728.5**
Y/Y Growth	--	*23.6%*	*19.9%*	*17.6%*	*18.9%*	*16.9%*	***Y/Y Growth***	***--***	***7.7%***	***10.9%***	***5.7%***	***4.2%***	***5.3%***
Total Physical IP	**893.1**	**952.0**	**1,047.1**	**1,112.7**	**1,161.6**	**1,277.1**							
Y/Y Growth	***--***	***6.6%***	***10.0%***	***6.3%***	***4.4%***	***9.9%***							

Source: Gartner Forecast: Semiconductor Design Intellectual Property, Worldwide, 2015 Update, by Ganesh Ramamoorthy, December 31, 2015, RBC Capital Markets

Connector companies (APH, TEL, and ST)

We expect connector and sensor companies like Amphenol (Top Pick, $63 target), TE Connectivity (Outperform, $65 target), and Sensata Technologies (Sector Perform, $40 target) to benefit from IoT as the demand for sensors (to sense physical phenomena like temperature, pressure, humidity, etc.) and connectors (to transmit the data) will inflect higher especially across key verticals like automotive and industrial.

The industrial segment accounted for $6.3 billion connector sales in 2015. End-use products include machine tools, heavy equipment, robotics, vision systems, factory automation, instrumentation, rail mass transit, energy, and other production equipment used in harsh and hazardous environments. We believe this end-market should advance at a 5% CAGR through 2020, which would be higher than the historical CAGR of 3% (since 2005), on the growing proliferation of factory-floor automation equipment that collects, processes, and communicates data among devices.

The automotive segment at ~$12 billion in global sales is the largest end-market in the connector industry as it represents 23% of global connector sales. The automotive segment is mature from a revenue standpoint and has generated below-average growth rates relative to the connector industry average, generating a 2% CAGR since 2005 versus 4% CAGR, respectively. However, we think the automotive market could see an uptick in organic growth over the next several years driven by new emission standards, increased safety requirements, increased infotainment options, and other drivers that should ensure further "electronification" of vehicles. Specifically, content per vehicle could be as high as $600 based on: (1) the vehicle platform (agriculture and heavy vehicles are the highest); (2) region of the world (Europe is highest followed by North America); and (3) vehicle type (diesel engines and hybrids command higher content than direct gas injection). We estimate average content per light vehicle is $60–70 globally.

Exhibit 18: End-market exposure as a percentage of sales
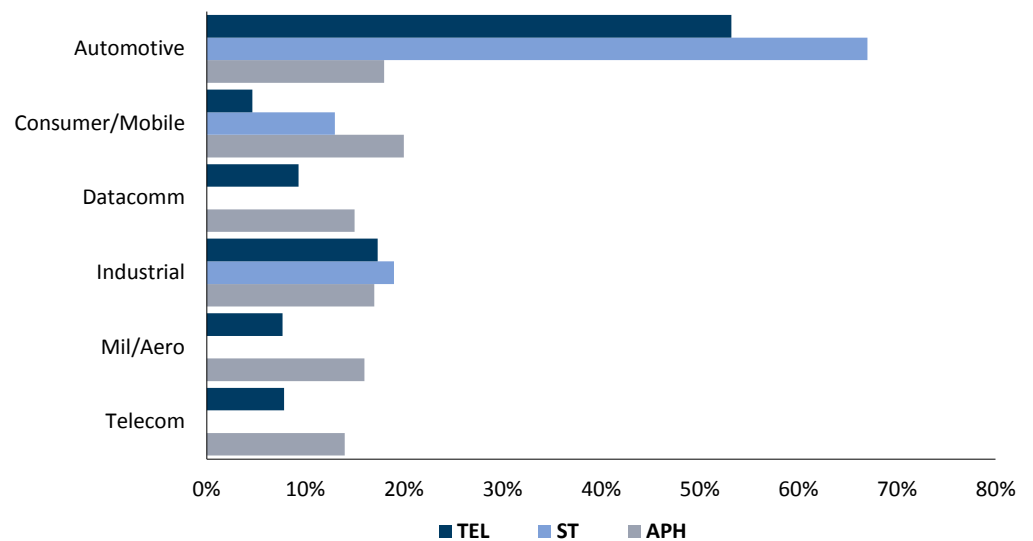
Source: Company reports, RBC Capital Markets

ST: Sales to key customers, the ability to win new programs, end-market demand, pricing, the pace of new product introductions and the ability to generate free cash flow, lower production costs, execute restructuring programs, and identify and integrate attractive acquisition candidates.
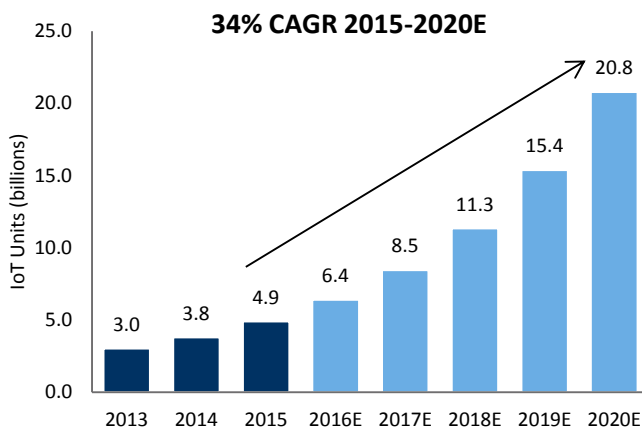
Market overview

Increase in connected devices

Gartner estimates that the number of connected devices has increased from ~3B in 2013 to ~5B in 2015. This number is expected to grow exponentially over the next several years as consumers and enterprises seek to gain competitive advantage offered by IoT: (1) reduce time to market; (2) improve supply chain and logistics; (3) achieve cost savings; and (4) increase employee productivity. The unit growth expectations for IoT-enabled devices vary greatly as IoT is still in its early innings. Gartner expects the number of connected devices to grow at a 34% CAGR to reach 20.8B devices by 2020, while Cisco anticipates the number to expand to 50.1B in 2020 from 18.2B in 2015 (22% CAGR). We believe the discrepancy is due to Cisco applying a broader definition of IoT units.

Exhibit 19: IoT unit growth forecast
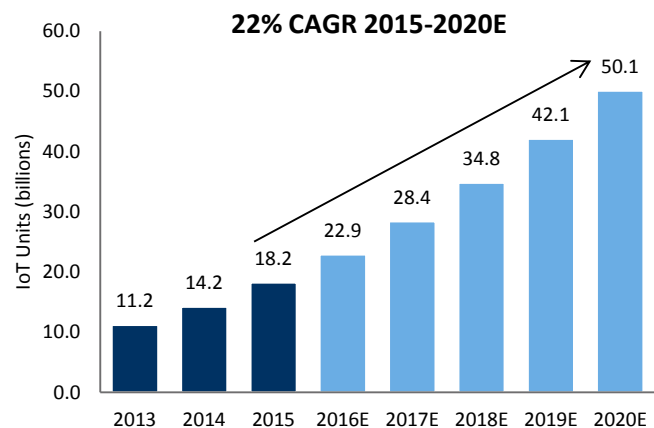
Source: Cisco, Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Looking at the IoT-installed base, approximately 60% are consumer applications, with enterprise (including public sector) making up the remaining 40%. The consumer segment has shown steady growth and represents an increasing portion of the unit mix (58% in 2013, 62% in 2015, and 65% expected in 2020). While the overall mix of enterprise applications is on a decline, we note that the cross-industry segment is gaining a greater share of the market and is expected to grow from 17% in 2015 to 21% by 2020.

Exhibit 20: IoT-installed base mix
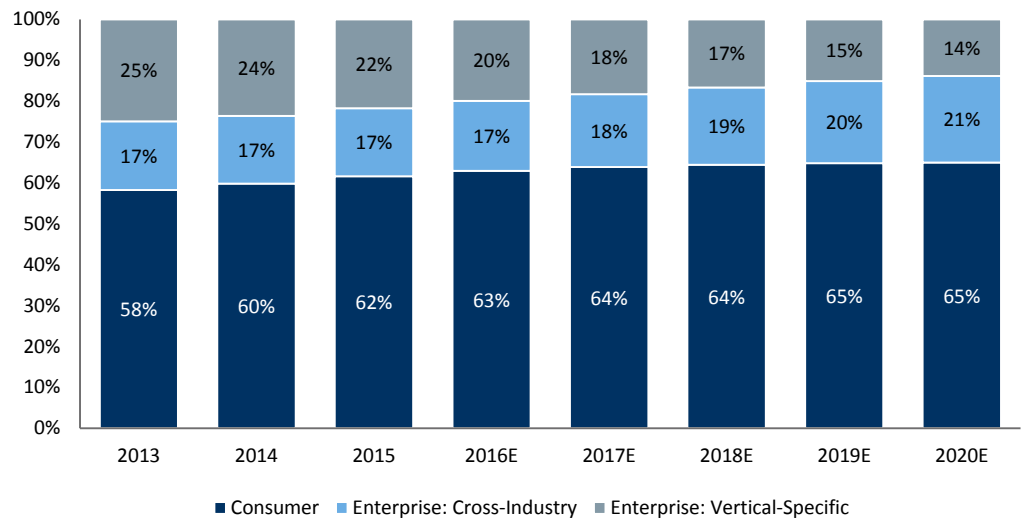
Consumer IoT

Consumer IoT brings connectivity to household appliances and personal devices. The total consumer IoT-installed base was 3.0B units in 2015 and is expected to grow to 13.5B units by 2020, representing a five-year CAGR of 35%.

Exhibit 21: Consumer IoT unit installed base (millions)

| Sector	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR 2015-2020E
Automotive	75	150	298	515	849	1,353	2,067	2,956	58%
Y/Y Growth	--	98%	99%	73%	65%	59%	53%	43%	
Health & Fitness	116	149	187	224	276	338	417	525	23%
Y/Y Growth	--	29%	25%	20%	23%	22%	23%	26%	
Home Automation	37	79	169	339	630	1,090	1,772	2,729	74%
Y/Y Growth	--	112%	114%	101%	86%	73%	63%	54%	
Home Energy	11	28	63	128	239	418	696	1,107	78%
Y/Y Growth	--	151%	121%	104%	87%	74%	67%	59%	
Home Security	16	38	90	191	357	605	952	1,419	74%
Y/Y Growth	--	140%	136%	112%	87%	69%	57%	49%	
Information & Entertainment	1,512	1,833	2,216	2,627	3,051	3,513	4,066	4,773	17%
Y/Y Growth	--	21%	21%	19%	16%	15%	16%	17%	
Total	**1,768**	**2,277**	**3,023**	**4,024**	**5,403**	**7,316**	**9,970**	**13,509**	**35%**
Y/Y Growth	--	29%	33%	33%	34%	35%	36%	35%	

Within the consumer market, information and entertainment, which include the familiar smart TVs, set-top boxes (STBs), and wireless speakers, account for 2.2B units or nearly three-quarters of the total consumer IoT devices. This segment is expected to grow at a healthy mid-teen rate annually to 4.8B units in 2020. While the growth of information and entertainment IoT units should remain stable, the adoption rate is expected to be lower than growth in the aggregate consumer market, thereby giving way to new and emerging technologies such as connected cars and smart homes. In 2020, we expect information and entertainment devices to make up ~35% of total consumer IoT units.

Exhibit 22: Information & entertainment installed base

Information & entertainment unit forecast
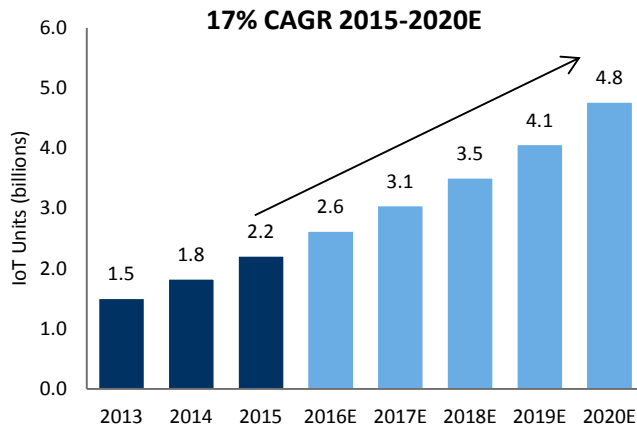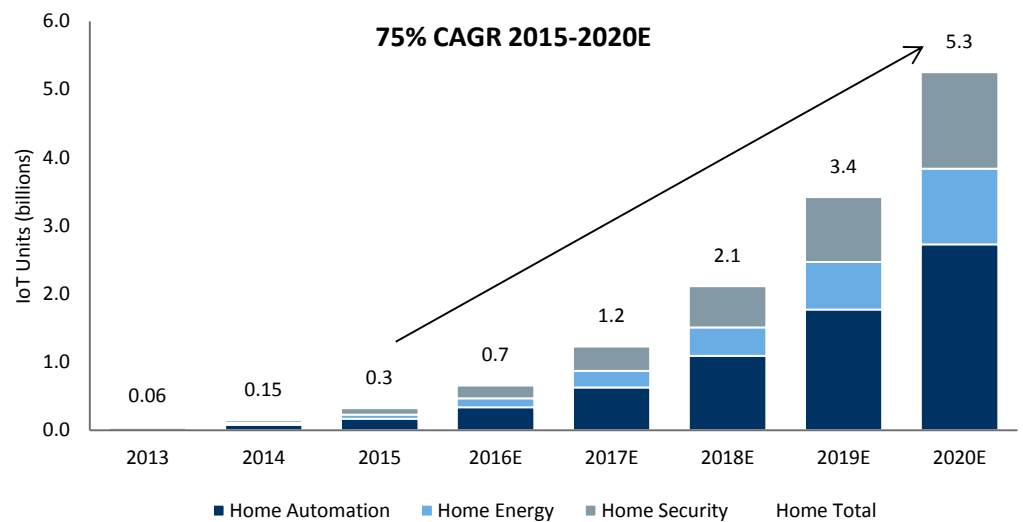

Consumer IoT units mix
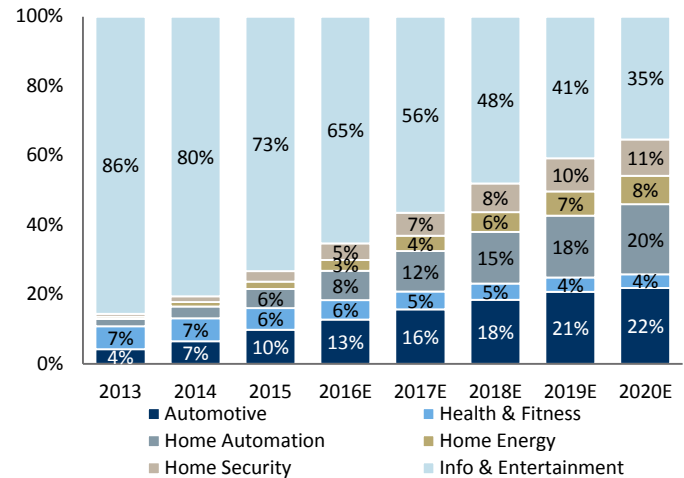
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

The adoption rate for smart home solutions, which include home automation, home energy management, and home security, is growing at a rapid pace, more than twice the rate of overall consumer IoT products. The home automation segment is fragmented, with a wide range of appliances and tools, including consumer robots and connected kitchen appliances such as refrigerators, stoves, and microwaves. The number of IoT-enabled home automation devices was 169M in 2015 and is expected to grow at 74% CAGR to 2.7B by 2020.

The home energy management sector includes connected devices that can be controlled remotely to monitor power consumption and achieve energy efficiency. For example, Philips Hue light bulbs can be controlled remotely using a smartphone or a tablet to turn the light on/off, adjust brightness, and change colors, and Google Nest automates thermostat capabilities based on usage patterns. In 2015, the installed base for IoT-enabled home energy units was 63M. The usage is expected to increase at ~78% annually to reach 1.1B units in 2020.

The final segment of the connected home is home security, which uses sensors to detect intrusion and automatically alerts the police and the homeowner. The number of home security units was 90M in 2015 and is expected to reach 1.4B in 2020 at a CAGR of 74%.
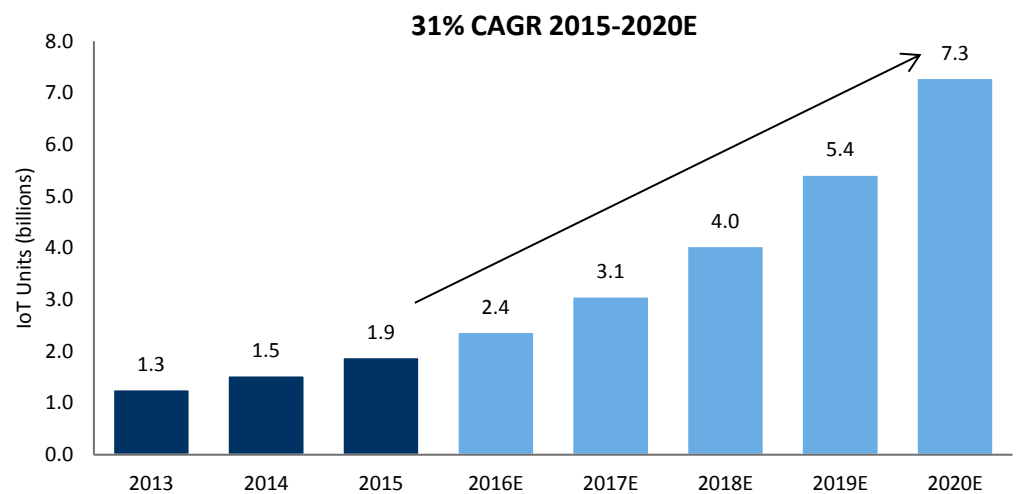
Exhibit 23: Smart home devices

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Enterprise IoT

IoT has become a key enabler for enterprises as they seek to manage better the physical assets that are relevant to the business. Through IoT, businesses benefit from improved asset optimization and can discover new business opportunities. The enterprise IoT-installed base was 1.9B units in 2015 and it is expected to reach 7.3B in 2020.

Exhibit 24: Enterprise IoT-installed base

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Exhibit 25: Enterprise IoT unit installed base (millions)

Category	Sector	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR 2015-2020E
Cross-Industry	Automotive	13	28	58	106	183	307	493	738	66%
	Y/Y Growth	--	*110%*	*110%*	*81%*	*73%*	*68%*	*60%*	*50%*	
	Energy	17	25	44	89	183	356	645	1,074	89%
	Y/Y Growth	--	*53%*	*74%*	*103%*	*105%*	*94%*	*81%*	*67%*	
	Information	304	324	349	383	423	472	532	605	12%
	Y/Y Growth	--	*7%*	*8%*	*10%*	*10%*	*12%*	*13%*	*14%*	
	Safety	2	3	6	10	17	26	38	55	56%
	Y/Y Growth	--	*88%*	*73%*	*73%*	*62%*	*55%*	*49%*	*43%*	
	Building or Facilities Automation/Other	8	22	47	94	173	301	499	788	76%
	Y/Y Growth	--	*159%*	*118%*	*99%*	*85%*	*74%*	*65%*	*58%*	
	Physical Security	167	230	310	409	531	684	884	1,148	30%
	Y/Y Growth	--	*37%*	*35%*	*32%*	*30%*	*29%*	*29%*	*30%*	
	Cross-Industry Total	**511**	**636**	**819**	**1,095**	**1,514**	**2,149**	**3,093**	**4,410**	**40%**
	Y/Y Growth	**--**	***25%***	***29%***	***34%***	***38%***	***42%***	***44%***	***43%***	
Vertical-Specific	Education	4	6	9	14	23	35	54	79	54%
	Y/Y Growth	--	*44%*	*48%*	*57%*	*58%*	*56%*	*53%*	*47%*	
	Government	58	87	123	166	219	276	342	419	28%
	Y/Y Growth	--	*51%*	*41%*	*35%*	*31%*	*26%*	*24%*	*22%*	
	Healthcare Providers	36	44	53	64	78	94	112	133	20%
	Y/Y Growth	--	*21%*	*21%*	*21%*	*21%*	*20%*	*20%*	*19%*	
	Manufacturing & Natural Resources	290	324	358	401	453	514	588	677	14%
	Y/Y Growth	--	*12%*	*10%*	*12%*	*13%*	*14%*	*14%*	*15%*	
	Transportation	115	140	169	201	238	278	323	372	17%
	Y/Y Growth	--	*22%*	*20%*	*19%*	*18%*	*17%*	*16%*	*15%*	
	Utilities	218	259	308	369	445	539	653	790	21%
	Y/Y Growth	--	*19%*	*19%*	*20%*	*21%*	*21%*	*21%*	*21%*	
	Banking & Securities	3	3	4	4	4	4	4	4	3%
	Y/Y Growth	--	*4%*	*4%*	*3%*	*3%*	*3%*	*3%*	*3%*	
	Retail & Wholesale Trade	31	34	41	56	87	146	247	405	58%
	Y/Y Growth	--	*12%*	*20%*	*36%*	*55%*	*68%*	*69%*	*64%*	
	Vertical-Specific Total	**756**	**900**	**1,066**	**1,278**	**1,547**	**1,888**	**2,325**	**2,881**	**22%**
	Y/Y Growth	**--**	***19%***	***18%***	***20%***	***21%***	***22%***	***23%***	***24%***	
Total		**1,266**	**1,536**	**1,885**	**2,373**	**3,061**	**4,036**	**5,418**	**7,291**	**31%**
Y/Y Growth		**--**	*21%*	*23%*	*26%*	*29%*	*32%*	*34%*	*35%*	

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Enterprise IoT is further broken down into two categories: cross-industry and vertical-specific. Cross-industry includes applications that can be used in multiple industries. This category has been outpacing both the consumer and vertical-specific segments, and we expect the momentum to continue through the back half of the decade. The installed base for the cross-industry was 819M units in 2015, and we estimate the segment to grow at 40% CAGR to 4.4B in 2020.

Exhibit 26: Cross-industry installed base

Cross-industry unit forecast
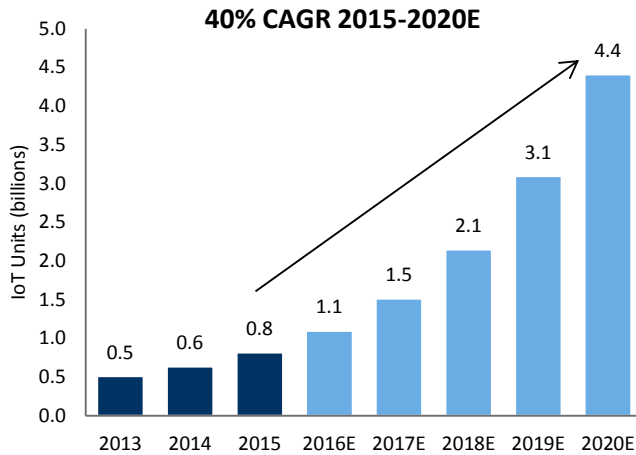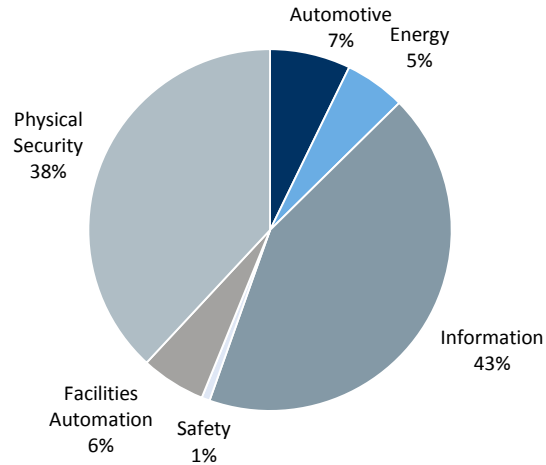
40% CAGR 2015-2020E

Unit share (2015)

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Information and physical security make up the lion's share of the cross-industry units, with ~80% share in aggregate. The information segment includes networked printers, scanners, and digital signage, and it is expected to grow from 349M units in 2015 to 605M units in 2020 at a CAGR of 12%. Physical security includes networked security cameras, electronic door locks, and other surveillance technologies, and it is expected to grow from 310M units in 2015 to 1.15B units in 2020 at a CAGR of 30%. With growth in both end-markets trailing the overall cross-industry segment, we expect their shares steadily to decline long term as adoption in higher-growth industries ramps up.

Exhibit 27: Information and physical security installed base

Information
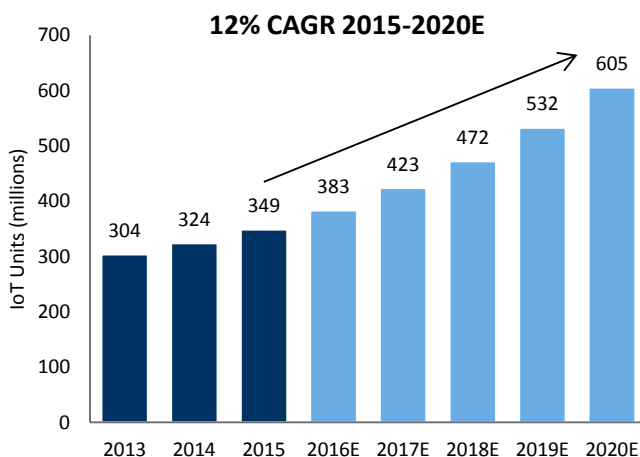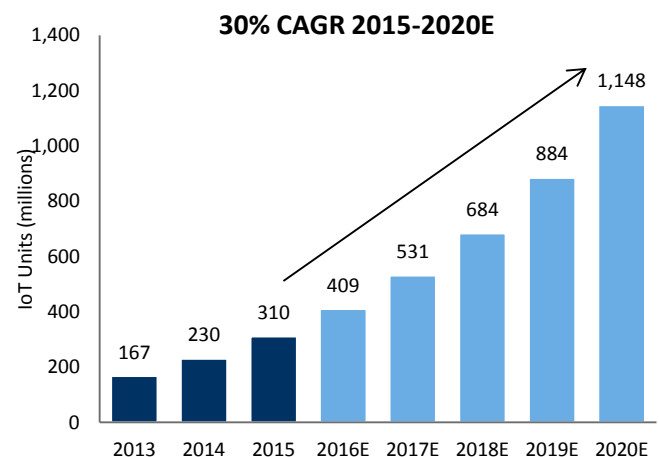
12% CAGR 2015-2020E

Physical security

30% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

In terms of growth, the automotive and energy sectors are expected to drive IoT adoption in the cross-industry segment. Similar to the consumer automotive segment, the advancement in infotainment systems, coupled with wireless and tethering capabilities, is currently leading the transition to connected cars. The installed base for the automotive vertical was 58M in 2015 and is expected to reach 738M by 2020, representing a five-year CAGR of 66%. Growth

in the energy management vertical is expected to be driven by adoption of light-emitting diode (LED) applications. The installed base for the energy management vertical was 44M in 2015 and is expected to reach 1.1B by 2020, growing at a CAGR of 89%.
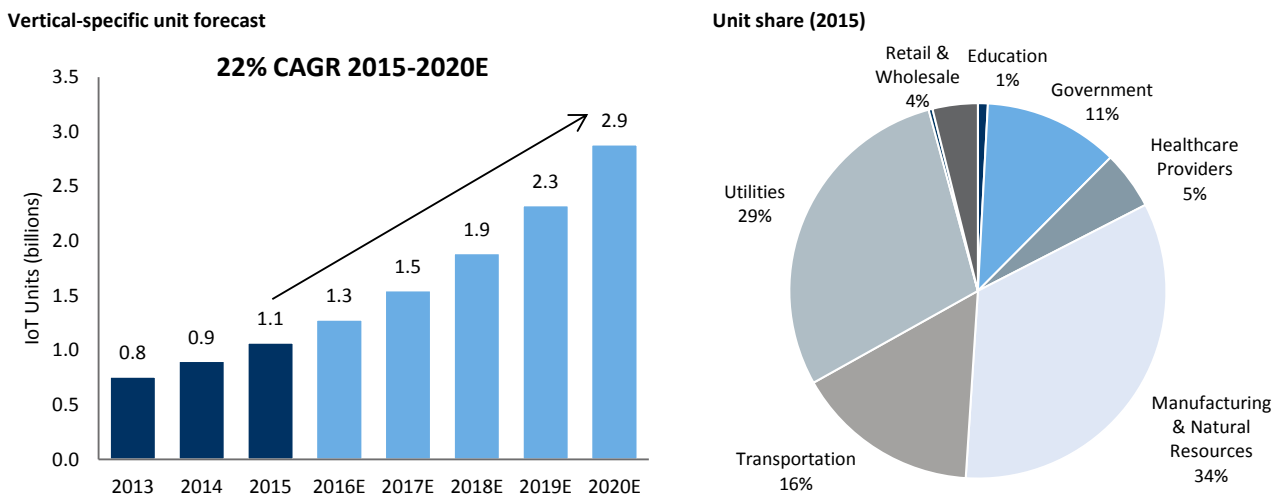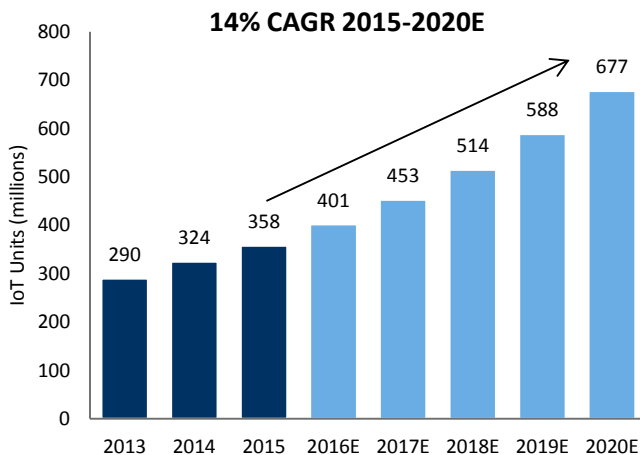
Exhibit 28: Automotive and energy vertical installed base
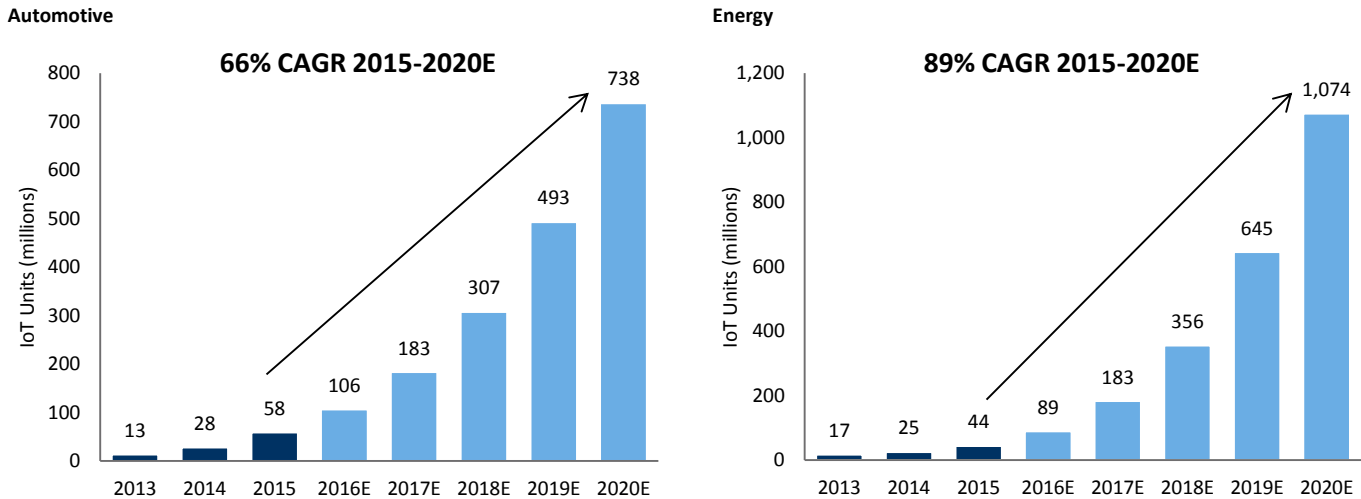
Automotive

Energy

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

The vertical-specific category includes applications developed and tailored to specific industries, including education, manufacturing, healthcare, transportation, retail/wholesale, utilities, and financial services. The public sector is also included in this category. It is the slowest-growing segment due to the underlying nature of the category: (1) vertical-specific solutions cannot be utilized in other industries, thereby limiting their adoption; and (2) the industries within the category often use assets for longer periods and are slow in adopting new technologies. The installed base for the vertical-specific category was 1.1B in 2015 and is expected to reach 2.9B by 2020 at a CAGR of 22%.

Exhibit 29: Vertical-specific installed base

Vertical-specific unit forecast

Unit share (2015)

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Within the segment, manufacturing and natural resources is the highest contributor accounting for ~34% of the installed base. The number of IoT-enabled units for this industry is expected to grow at a five-year CAGR of 14% from 358M in 2015 to 677M in 2020. Following the manufacturing and natural resources vertical, utilities is the next highest contributor with ~29% share. The installed base for the utilities industry is expected to grow at a five-year CAGR of 21% from 308M in 2015 to 790M in 2020.

Exhibit 30: Manufacturing & natural resources and utilities vertical installed base

Manufacturing & natural resources
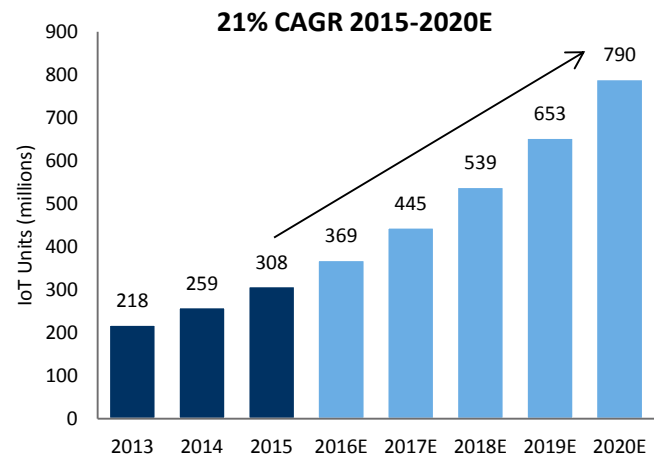
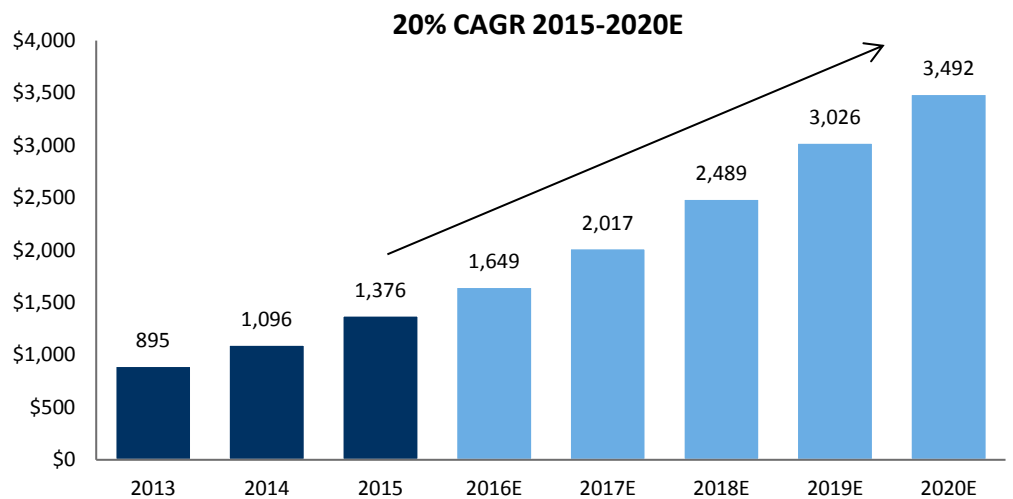**14% CAGR 2015-2020E**

Utilities

21% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

In terms of growth, the education and retail/wholesale trade verticals are expected to drive IoT adoption. Both segments are expanding faster than the aggregate vertical-specific category and are expected to be a larger contributor going forward. The IoT-installed base for the education sector was 9M in 2015 and is expected to grow at 54% CAGR to reach 79M in 2020. The installed base for the retail & wholesale trade sector was 41M in 2015 and is expected to grow at 58% CAGR to reach 405M in 2020.

Exhibit 31: Education and retail& wholesale trade installed base

Education
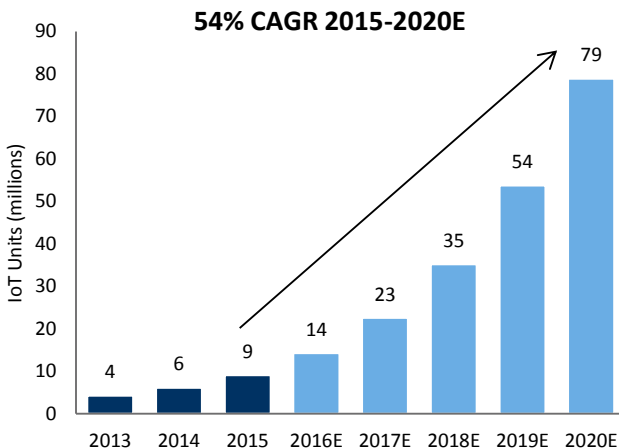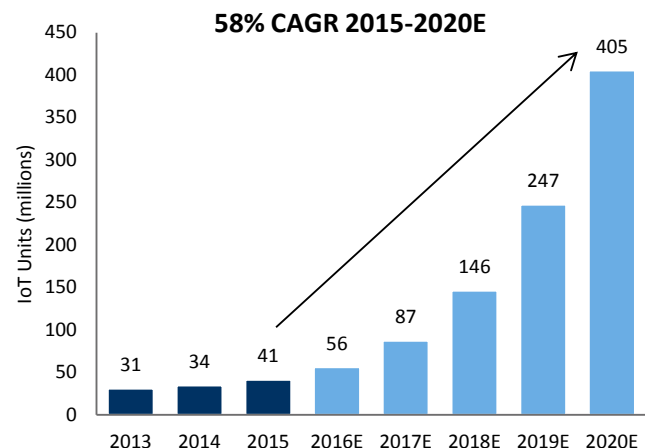
54% CAGR 2015-2020E
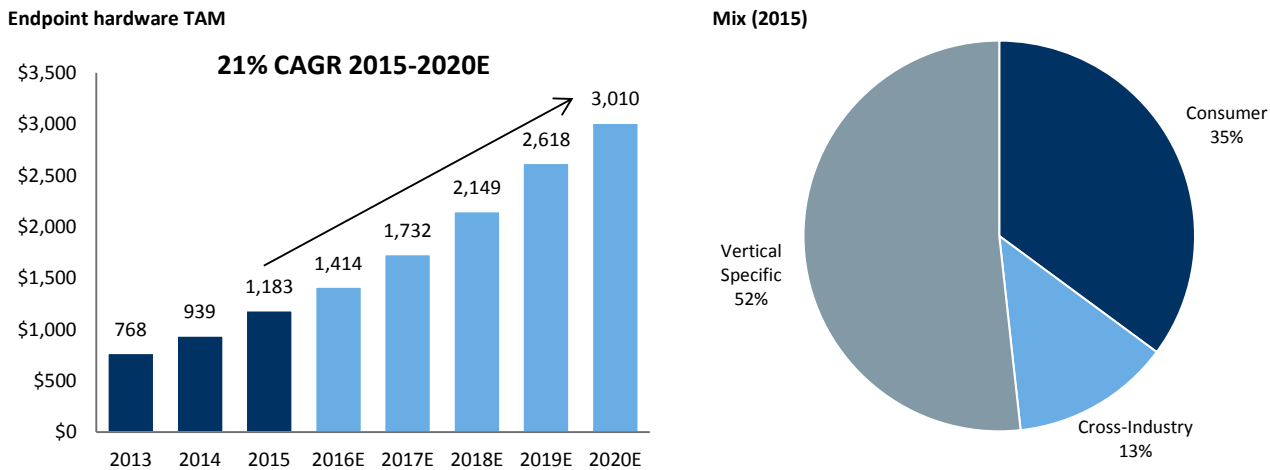
Retail & wholesale trade

58% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Total addressable market (TAM)

The IoT market is still largely under-penetrated and represents a sizable opportunity for vendors. However, it is difficult to quantify the IoT opportunity as the concept spans multiple products, industries, and end-markets. In our analysis, we summed end-user spending on new IoT endpoint hardware with the external services revenue required over the product lifecycle to estimate the TAM. We value the overall market opportunity at $1.4T, which is expected to grow to $3.5T by 2020, representing a CAGR of 20%. The TAM is mostly made up of the IoT hardware market representing 86% of the total market, with services mix at 14%. We examine each component of the TAM below.

Exhibit 32: IoT addressable market ($B)

20% CAGR 2015-2020E

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E
	895	1,096	1,376	1,649	2,017	2,489	3,026	3,492

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Endpoint hardware market

Combined IoT endpoint hardware spending is valued at $1.2T in 2015 and expected to grow at a CAGR of 21% in 2015-2020 to $3T by 2020. The endpoint hardware market consists of consumer and enterprise sub-segments. The consumer market accounts for ~35% of the total hardware TAM, while enterprise (including government) makes up 65% of the pie. Within the enterprise segment, the vertical-specific category dominates, representing ~80% share or 52% of the entire IoT endpoint hardware market. Cross-industry represents ~20% of the enterprise category or 13% of the aggregate IoT hardware market.

Exhibit 33: Endpoint hardware TAM and mix ($B)

Endpoint hardware TAM

21% CAGR 2015-2020E

Year	Value
2013	768
2014	939
2015	1,183
2016E	1,414
2017E	1,732
2018E	2,149
2019E	2,618
2020E	3,010

Mix (2015)

Consumer 35%

Cross-Industry 13%

Vertical Specific 52%

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Consumer endpoint hardware spending

In 2015, total spending in the consumer space was $416B, up 62% y/y from $257B in 2014. The consumer market is expected to reach $1.53T in 2020, growing at an average annual growth rate of ~30%.

Exhibit 34: IoT endpoint spending – consumer ($B)

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR 2015-2020E
Automotive	80.8	152.3	284.7	389.9	558.2	792.8	1,045.7	1,217.2	34%
Y/Y Growth	*--*	*89%*	*87%*	*37%*	*43%*	*42%*	*32%*	*16%*	
Health and Fitness	12.3	14.2	17.0	19.7	23.9	27.5	31.0	35.5	16%
Y/Y Growth	*--*	*16%*	*20%*	*16%*	*21%*	*15%*	*13%*	*15%*	
Home Automation	4.3	8.3	15.6	25.4	36.9	50.2	65.3	81.8	39%
Y/Y Growth	*--*	*94%*	*87%*	*63%*	*46%*	*36%*	*30%*	*25%*	
Home Energy	3.1	3.4	3.9	4.8	6.0	7.8	10.0	12.6	26%
Y/Y Growth	*--*	*9%*	*15%*	*22%*	*26%*	*28%*	*29%*	*27%*	
Home Security	1.0	2.1	4.1	6.5	8.5	9.8	10.9	12.1	24%
Y/Y Growth	*--*	*118%*	*99%*	*58%*	*30%*	*16%*	*11%*	*11%*	
Information & Entertainment	64.2	76.7	90.3	99.9	112.7	127.6	149.8	174.5	14%
Y/Y Growth	*--*	*19%*	*18%*	*11%*	*13%*	*13%*	*17%*	*16%*	
Total	**165.6**	**257.0**	**415.6**	**546.2**	**746.2**	**1,015.8**	**1,312.6**	**1,533.7**	**30%**
Y/Y Growth	***--***	***55%***	***62%***	***31%***	***37%***	***36%***	***29%***	***17%***	

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets
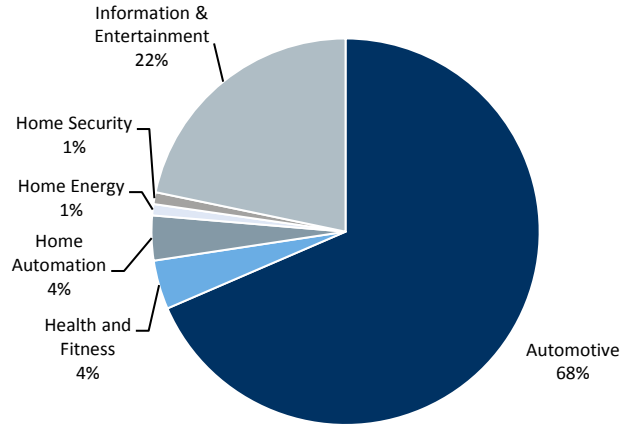
The consumer market is dominated by the automotive and information and entertainment segments, which account for a combined ~90% of the total consumer IoT spending. The automotive market was $285B in 2015, representing 68% of the total spending. This segment has grown rapidly as more cars are fitted with modems for wireless connectivity and smart diagnostic tools to monitor the health of the vehicle. With the ongoing advances in self-driving vehicles, we expect the segment to be a steady growth driver in the coming years. The automotive segment is expected to be a $1.22T market by 2020, growing faster than the overall consumer market, with a five-year CAGR of 34% (versus 30% for the aggregate consumer market). The annual growth rate is expected to taper in 2020, as penetration is expected to reach over 60% of sales, thereby limiting growth opportunities.

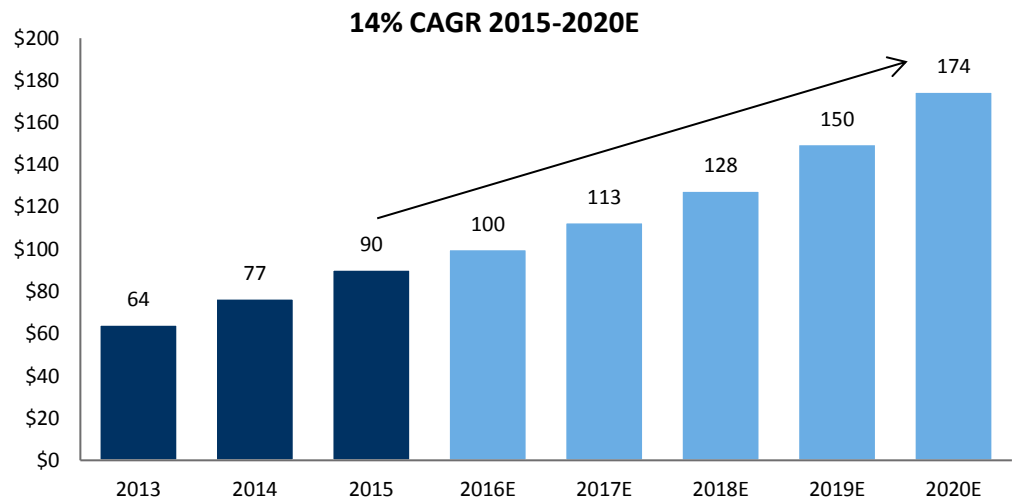Exhibit 35: Automotive IoT endpoint spending and consumer mix ($B)

Automotive
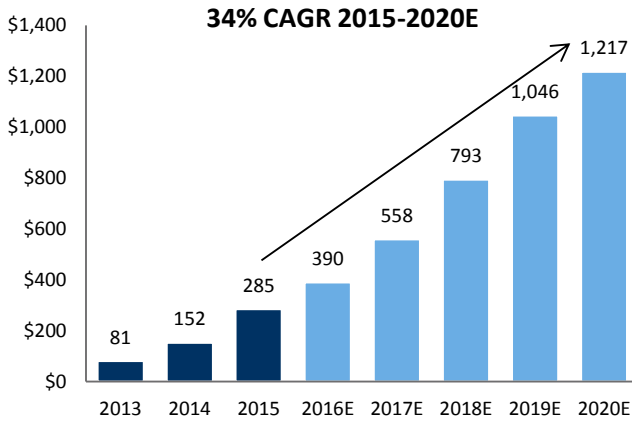
34% CAGR 2015-2020E

Year	Value
2013	81
2014	152
2015	285
2016E	390
2017E	558
2018E	793
2019E	1,046
2020E	1,217

Consumer mix (2015)

- Information & Entertainment 22%
- Home Security 1%
- Home Energy 1%
- Home Automation 4%
- Health and Fitness 4%
- Automotive 68%

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Information and entertainment, which accounts for ~22% of the total consumer market at $90B, is the second-largest segment following automotive. This end-market is heavily saturated, and growth is expected to remain below overall market growth. The information and entertainment vertical is expected to expand to a $174B market opportunity in 2020, with a five-year CAGR of 14%.

Exhibit 36: Information & entertainment IoT endpoint spending ($B)

14% CAGR 2015-2020E

Year	Value
2013	64
2014	77
2015	90
2016E	100
2017E	113
2018E	128
2019E	150
2020E	174

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

While the home automation, home energy, and home security segments represent only ~6% of the total spending in aggregate, we anticipate these end-markets will expand substantially in the coming years as new connected home solutions come into the market. The three sectors in aggregate are expected to outpace the overall market in the next five years (35% versus 30%) and represent a combined 7% share of the consumer market by 2020. Looking at individual segments, home automation is expected to outgrow the consumer market, while growth in home energy and home security is expected to come in slightly below: (1) home automation represented a $16B market in 2015, growing to $82B in 2020 (39% CAGR); (2)

home energy TAM was $4B in 2015, growing to $13B in 2020 (27% CAGR); and (3) home security TAM was $4B in 2015, growing to $12B in 2020 (24% CAGR).

Exhibit 37: Connected home endpoint spending ($B)
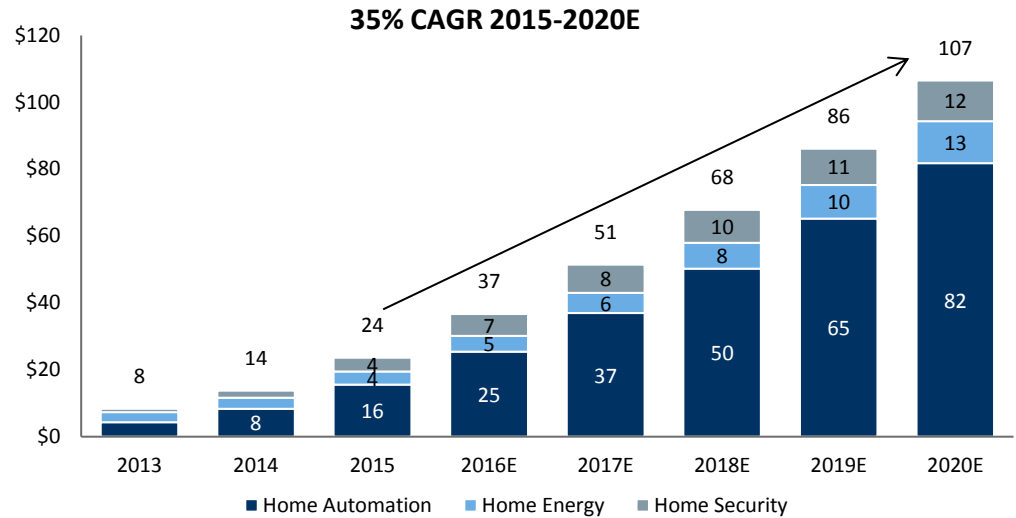
35% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Enterprise endpoint hardware spending

The enterprise IoT is a $770B market, poised to expand to $1.48T in 2020 with a five-year CAGR of 14%. While the enterprise IoT is largely expected to trail the growth of the consumer IoT market, we believe that business applications will generate greater value to enterprises through better asset utilization, improved employee productivity, reduced time to market, and increased customer lifetime value.

Exhibit 38: IoT endpoint spending – enterprise ($B)

Category	Sector	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR 2015-2020E
Cross-Industry	Automotive	13.4	26.8	53.1	77.0	116.9	175.9	245.9	303.3	42%
	Y/Y Growth	--	*100%*	*98%*	*45%*	*52%*	*51%*	*40%*	*23%*	
	Energy	7.2	8.3	9.6	11.5	14.0	17.0	20.5	23.9	20%
	Y/Y Growth	--	*15%*	*15%*	*20%*	*21%*	*22%*	*21%*	*17%*	
	Information	44.7	47.5	49.5	54.2	58.5	61.8	64.4	66.3	6%
	Y/Y Growth	--	*6%*	*4%*	*9%*	*8%*	*5%*	*4%*	*3%*	
	Safety	0.2	0.3	0.4	0.5	0.6	0.8	0.9	0.9	20%
	Y/Y Growth	--	*39%*	*36%*	*30%*	*25%*	*19%*	*15%*	*10%*	
	Building or Facilities Automation/Other	14.4	20.2	28.7	40.4	55.9	76.3	101.9	134.1	36%
	Y/Y Growth	--	*41%*	*42%*	*41%*	*38%*	*36%*	*34%*	*32%*	
	Physical Security	10.1	11.8	14.1	17.8	22.2	27.0	31.9	37.1	21%
	Y/Y Growth	--	*17%*	*20%*	*26%*	*25%*	*22%*	*18%*	*16%*	
	Cross-Industry Total	**90.0**	**117.0**	**157.3**	**202.9**	**269.6**	**360.1**	**466.6**	**566.5**	**29%**
	Y/Y Growth	**--**	***30%***	***35%***	***29%***	***33%***	***34%***	***30%***	***21%***	
Vertical-Specific	Education	1.4	1.8	2.5	3.5	4.9	6.5	8.1	9.6	31%
	Y/Y Growth	--	*29%*	*41%*	*43%*	*39%*	*32%*	*25%*	*18%*	
	Government	151.4	159.0	166.5	175.2	183.8	192.6	201.1	209.8	5%
	Y/Y Growth	--	*5%*	*5%*	*5%*	*5%*	*5%*	*4%*	*4%*	
	Healthcare Providers	8.9	10.3	12.0	14.0	16.7	19.7	22.7	25.6	16%
	Y/Y Growth	--	*16%*	*16%*	*17%*	*19%*	*18%*	*15%*	*13%*	
	Manufacturing & Natural Resources	71.9	81.5	84.5	95.3	103.7	114.2	124.2	136.2	10%
	Y/Y Growth	--	*13%*	*4%*	*13%*	*9%*	*10%*	*9%*	*10%*	
	Transportation	262.5	295.4	325.7	354.9	381.6	411.7	450.1	491.6	9%
	Y/Y Growth	--	*13%*	*10%*	*9%*	*8%*	*8%*	*9%*	*9%*	
	Utilities	7.9	9.5	11.0	12.9	15.2	17.7	20.4	23.2	16%
	Y/Y Growth	--	*21%*	*16%*	*17%*	*17%*	*16%*	*15%*	*14%*	
	Banking & Securities	1.5	1.6	1.6	1.7	1.7	1.7	1.8	1.8	2%
	Y/Y Growth	--	*2%*	*3%*	*3%*	*2%*	*2%*	*2%*	*2%*	
	Retail & Wholesale Trade	7.4	7.9	8.4	9.0	9.8	10.7	11.8	13.1	9%
	Y/Y Growth	--	*6%*	*6%*	*7%*	*9%*	*10%*	*10%*	*11%*	
	Vertical-Specific Total	**512.8**	**567.9**	**613.1**	**667.6**	**718.4**	**775.8**	**841.0**	**911.5**	**8%**
	Y/Y Growth	**--**	***11%***	***8%***	***9%***	***8%***	***8%***	***8%***	***8%***	
Total		**602.9**	**684.8**	**770.4**	**870.5**	**988.0**	**1,135.9**	**1,307.6**	**1,478.0**	**14%**
Y/Y Growth		**--**	***14%***	***12%***	***13%***	***14%***	***15%***	***15%***	***13%***	

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Unsurprisingly, we see a similar growth trend appearing when comparing the cross-industry and vertical-specific segments as we did when analyzing the growth of IoT units and the installed base across the two categories. The cross-industry category is expected to outpace the slow-moving and mature industries in the vertical-specific category. The addressable market for the cross-industry category currently stands at ~$157B and accounts for ~20% of the total enterprise endpoint spend. This segment is expected to increase to $567B by 2020, growing at a CAGR of 29% and representing ~38% of the market.

Exhibit 39: Cross-industry IoT endpoint spending and mix ($B)
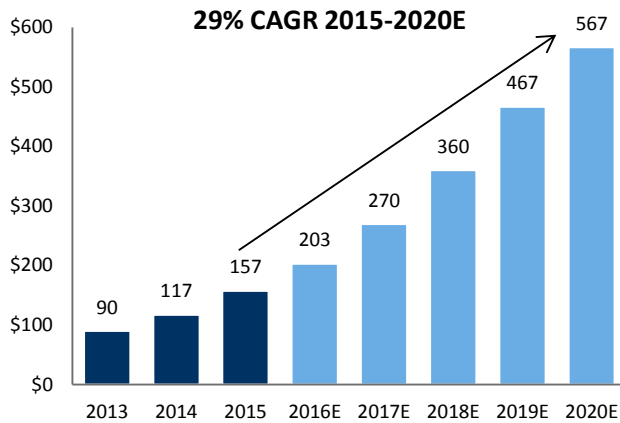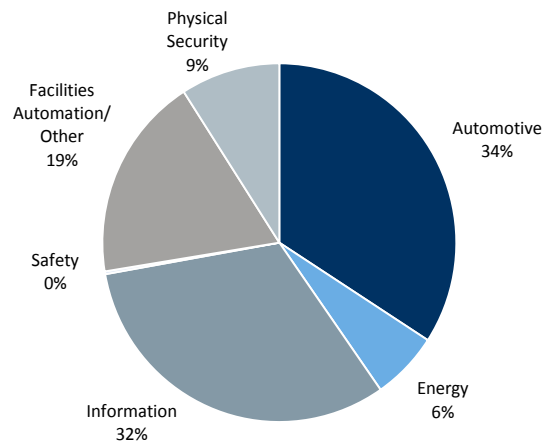
Endpoint spending

29% CAGR 2015-2020E

Mix (2015)

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets
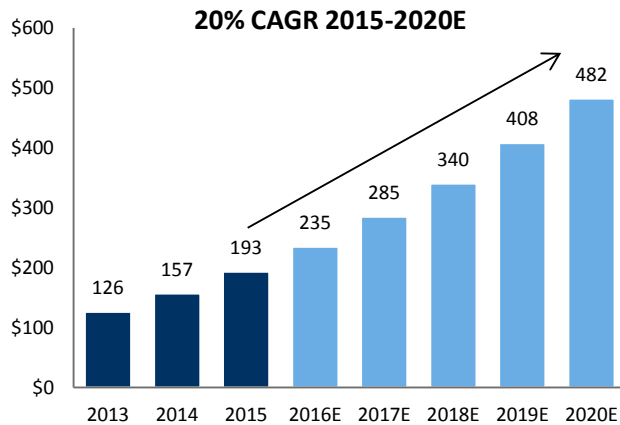
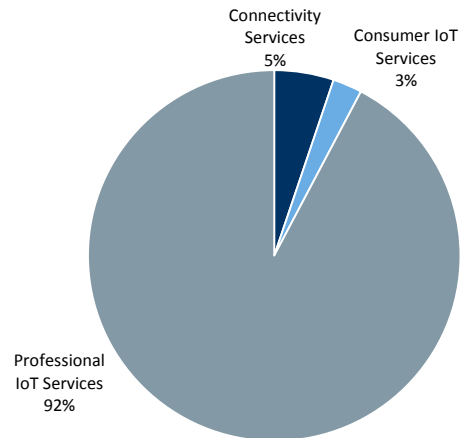Within the cross-industry segment, automotive and facilities automation respectively represent the largest and second-largest sectors in terms of both size and growth. The automotive industry is a $53B market, which is expected to increase at a CAGR of 42% to $303B by 2020, and accounts for 34% of cross-industry. The building/facilities automation industry represents a $29B market, which is expected to grow at a 36% CAGR to $134B by 2020. The sector accounts for ~18% of total cross-industry market.

Exhibit 40: Automotive and facilities automation/other IoT endpoint spending ($B)

Automotive
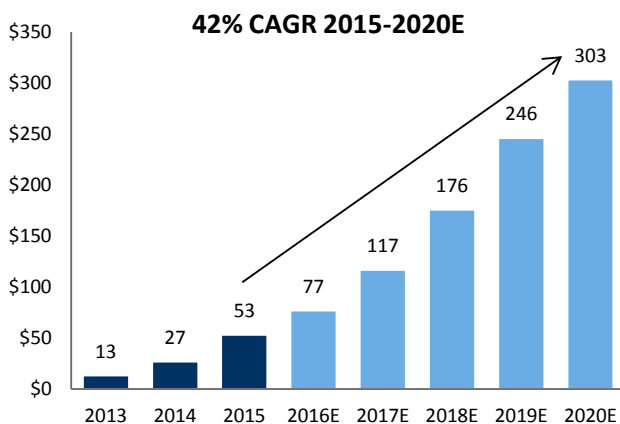
42% CAGR 2015-2020E

Facilities automation/other
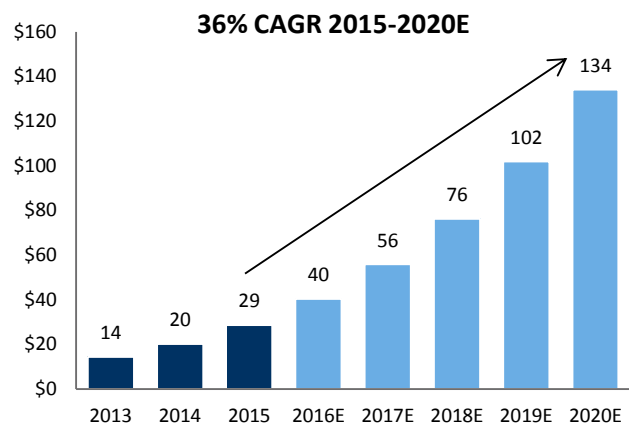
36% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Vertical-specific endpoint spending currently stands at $613B and accounts for 80% of the enterprise market. The category is expected to grow at a lower rate at ~8% CAGR (compared to 29% for cross-industry) in the 2015–2020 timeframe to $911B in 2020. Due to the lagging growth rates, the mix of the vertical-specific category within the enterprise market is expected to decline from 80% to 60% by 2020.

Exhibit 41: Vertical-specific IoT endpoint spending and mix ($B)
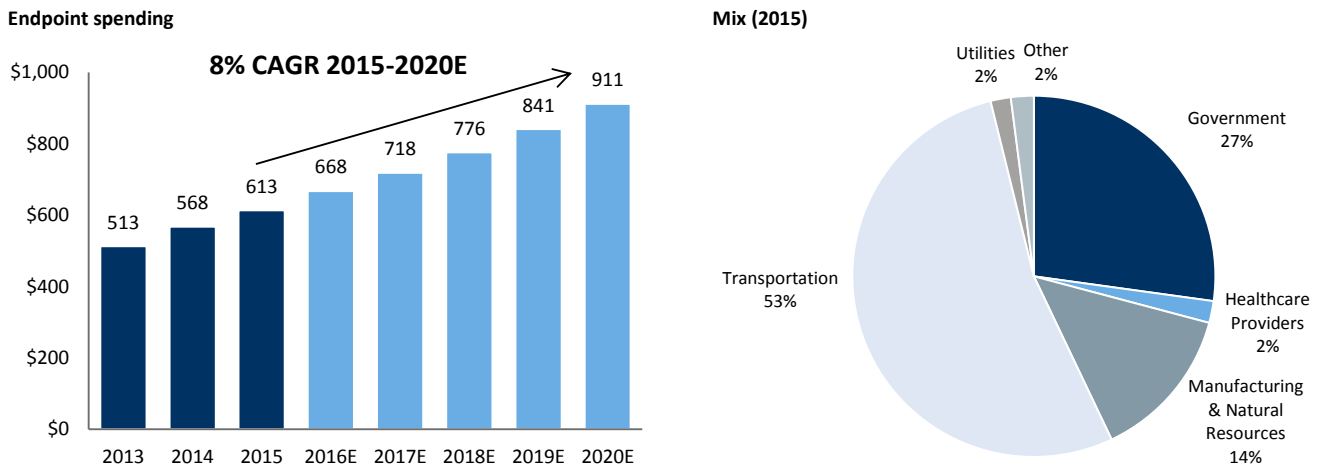
Endpoint spending

8% CAGR 2015-2020E

Mix (2015)

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Within the vertical-specific category, the transportation sector is the largest market at $326B. The transportation sector is expected to grow at high-single digits over the next few years and reach $492B in 2020 (9% CAGR). On a growth basis, education is the strongest sector at $2.5B and is expected to expand to $9.6B in 2020 at a CAGR of 31%. All other end-markets in the vertical-specific category are anticipated to expand from low-single digits to mid-teens on an annual basis.

Exhibit 42: Government and education IoT endpoint spending ($B)
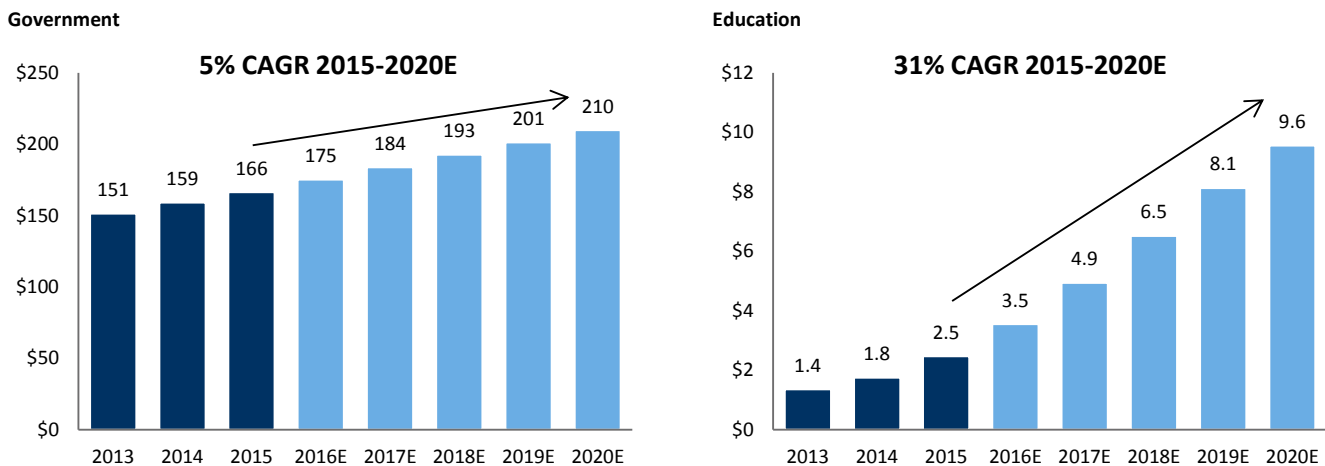
Government

5% CAGR 2015-2020E

Education

31% CAGR 2015-2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Services market

Besides the IoT vendors that manufacture the "things" such as sensors, modem chips, and other embedded technology, companies could also benefit from the IoT opportunity by offering connectivity, consumer, and professional IoT services. The combined services market is valued at $193B, on pace to reach ~$482B in 2020, growing at a CAGR of 20%. Within the services market, professional services account for 92% of revenues, followed by connectivity services at 5% and consumer services at 3%.

Exhibit 43: Services TAM and mix ($B)

Services TAM

20% CAGR 2015-2020E

Year	Value
2013	126
2014	157
2015	193
2016E	235
2017E	285
2018E	340
2019E	408
2020E	482

Mix (2015)

- Connectivity Services 5%
- Consumer IoT Services 3%
- Professional IoT Services 92%

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Connectivity services

Connectivity services involve providing WAN connectivity for the IoT devices, either directly or via a gateway. Connectivity services revenue only includes incremental data service fees incurred for network connections and excludes existing broadband and cellular plans for consumers, and existing corporate wide area networks (WANs) for enterprises are also excluded. The market for connectivity services was valued at $10B in 2015 and is expected to grow more than threefold to ~$31B in 2020 at a CAGR of 25%.

Exhibit 44: Connectivity services revenue ($M)

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR (%) 2015-2020E
Connected Car	74.0	143.1	276.1	517.1	927.6	1,723.2	3,336.2	6,963.6	91%
Y/Y Growth	--	*93%*	*93%*	*87%*	*79%*	*86%*	*94%*	*109%*	
Smart Electric Meters	635.7	792.0	985.0	1,226.0	1,526.5	1,901.5	2,369.5	2,955.2	25%
Y/Y Growth	--	*25%*	*24%*	*24%*	*25%*	*25%*	*25%*	*25%*	
Outdoor Security Camera	299.2	413.8	556.6	723.0	912.3	1,124.2	1,372.1	1,665.1	25%
Y/Y Growth	--	*38%*	*35%*	*30%*	*26%*	*23%*	*22%*	*21%*	
Connected Heavy Trucks	420.1	500.7	585.6	673.1	761.5	849.3	935.5	1,019.1	12%
Y/Y Growth	--	*19%*	*17%*	*15%*	*13%*	*12%*	*10%*	*9%*	
Remote Patient Monitoring	244.3	280.3	324.8	378.1	442.7	521.4	618.1	739.5	18%
Y/Y Growth	--	*15%*	*16%*	*16%*	*17%*	*18%*	*19%*	*20%*	
Home Security	40.0	68.0	111.8	174.5	256.8	353.7	439.2	520.0	36%
Y/Y Growth	--	*70%*	*65%*	*56%*	*47%*	*38%*	*24%*	*18%*	
Point-of-Sale Hardware	283.2	303.4	325.0	347.8	372.1	398.2	426.0	455.8	7%
Y/Y Growth	--	*7%*	*7%*	*7%*	*7%*	*7%*	*7%*	*7%*	
Outdoor Digital Signage	61.6	89.5	125.4	170.1	224.2	288.1	361.9	445.5	29%
Y/Y Growth	--	*45%*	*40%*	*36%*	*32%*	*29%*	*26%*	*23%*	
Smart Gas Meters	0.0	8.5	21.2	46.6	91.7	163.5	267.1	405.0	80%
Y/Y Growth	--	*--*	*149%*	*120%*	*97%*	*78%*	*63%*	*52%*	
Wearables	0.3	1.7	17.3	58.4	126.5	180.9	270.8	357.9	83%
Y/Y Growth	--	*434%*	*909%*	*238%*	*117%*	*43%*	*50%*	*32%*	
Other	3,180.0	4,978.4	6,642.2	8,303.2	9,857.4	11,220.4	12,342.2	13,194.5	15%
Y/Y Growth	--	*57%*	*33%*	*25%*	*19%*	*14%*	*10%*	*7%*	
Total	**5,228.6**	**7,571.0**	**9,964.5**	**12,613.8**	**15,498.2**	**19,122.6**	**23,913.1**	**31,010.4**	**25%**
Y/Y Growth	**--**	***45%***	***32%***	***27%***	***23%***	***23%***	***25%***	***30%***	

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets
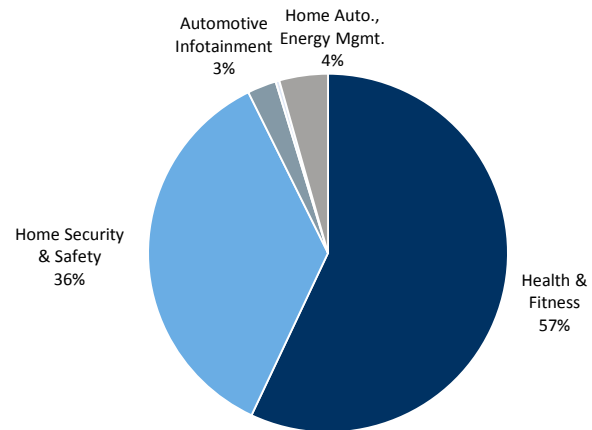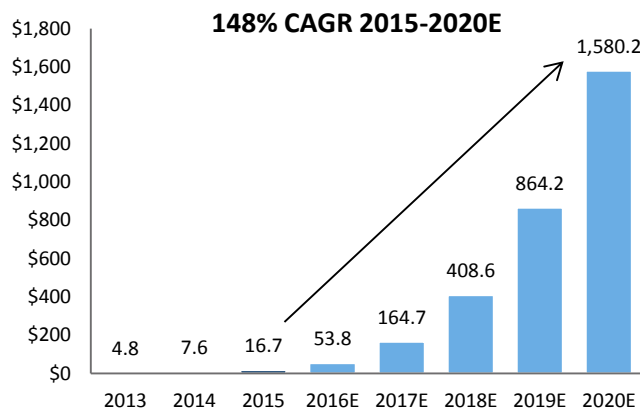
Analyzing the markets for connectivity services, we note that the top-five segments are well diversified across multiple industries, including automotive, energy, security, retail, and healthcare. In 2015, smart electric meters represented the largest mix of connectivity services at $985M, and accounted for ~10% of total connectivity services revenues with connected heavy trucks (6%), outdoor security camera (6%), point-of-sale hardware (3%), and remote patient monitoring (3%) rounding out the top five.

The mix is anticipated to shift in favour of the connected cars in the coming years due to the rapid interest in self-driving cars and the higher ARPU associated with the segment. By 2020, connected cars are expected to be the largest component of connectivity services representing 22% of the connectivity services revenue, followed by smart electric meters (10%), outdoor security cameras (5%), connected heavy trucks (3%), and remote patient monitoring (2%).

Exhibit 45: Top-5 segments in 2015 and 2020E ($M)
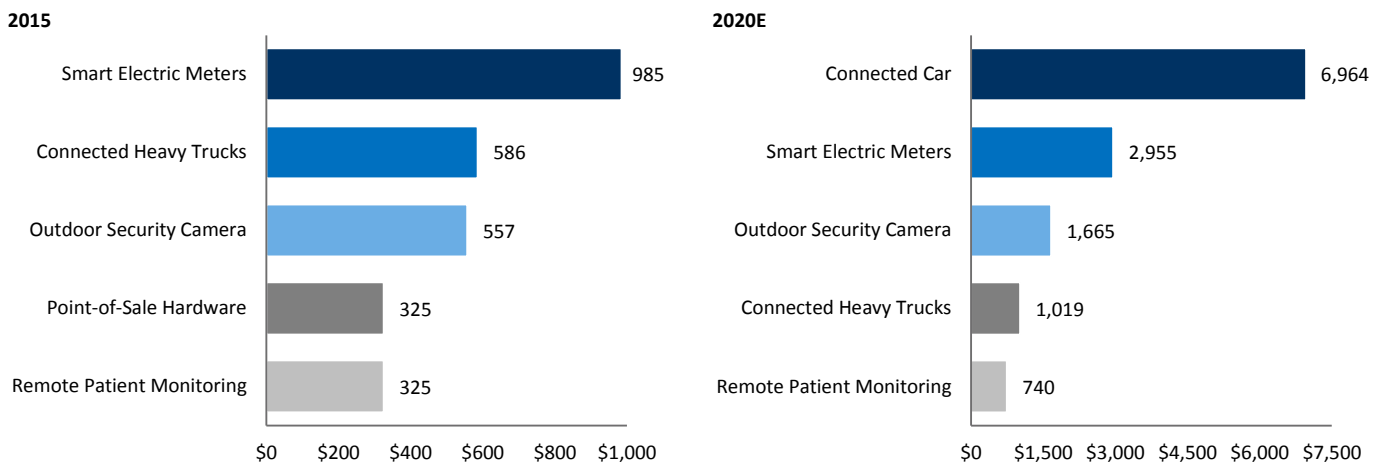
2015

2020E

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets
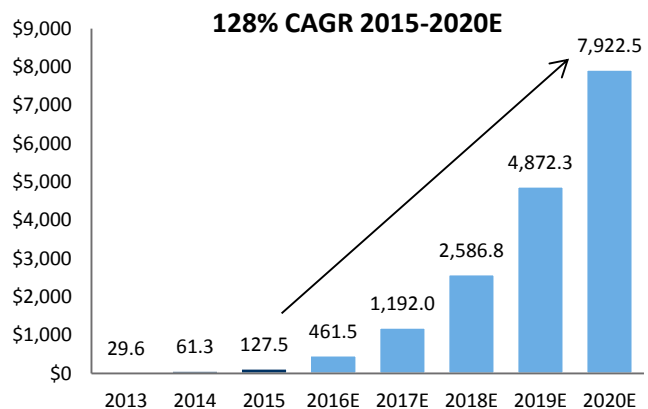
Consumer IoT services

Consumer services refer to the paid services offered directly to customers and represent the fastest-growing IoT services segment. The market size was $4.9B in 2015 and is expected to grow at a 52% CAGR to reach $39.2B by 2020. We note that the TAM represents only a fraction of the consumer market, as most customers are generally satisfied with using a free app.

Exhibit 46: Consumer IoT services revenue ($M)

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E	CAGR (%) 2015-2020E
Health and Fitness	1,630.8	1,879.2	2,796.4	3,422.6	5,682.9	8,240.8	12,616.8	18,079.8	45%
Y/Y Growth	*--*	*15%*	*49%*	*22%*	*66%*	*45%*	*53%*	*43%*	
Home Security and Safety	695.2	1,121.4	1,752.0	2,597.7	3,632.1	4,750.8	5,602.8	6,299.9	29%
Y/Y Growth	*--*	*61%*	*56%*	*48%*	*40%*	*31%*	*18%*	*12%*	
Automotive Infotainment	29.6	61.3	127.5	461.5	1,192.0	2,586.8	4,872.3	7,922.5	128%
Y/Y Growth	*--*	*107%*	*108%*	*262%*	*158%*	*117%*	*88%*	*63%*	
Information and Entertainment	4.8	7.6	16.7	53.8	164.7	408.6	864.2	1,580.2	148%
Y/Y Growth	*--*	*58%*	*120%*	*222%*	*206%*	*148%*	*112%*	*83%*	
Home Automation, Energy Management, Other	33.8	96.0	214.2	453.9	932.3	1,767.2	3,146.7	5,318.8	90%
Y/Y Growth	*--*	*184%*	*123%*	*112%*	*105%*	*90%*	*78%*	*69%*	
Total	**2,394.1**	**3,165.5**	**4,906.8**	**6,989.5**	**11,604.0**	**17,754.2**	**27,102.8**	**39,201.0**	**52%**
Y/Y Growth	*--*	*32%*	*55%*	*42%*	*66%*	*53%*	*53%*	*45%*	

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

The majority of the consumer services market is captured by the health and fitness segment, which represents ~57% of total consumer services revenue. The segment was $2.8B in 2015 and is expected to grow at a healthy annual rate of 45% to ~$18.1B in 2020. We believe growth in the health and fitness segment is largely driven by increased health awareness as well as insurance and employer programs that subsidize some of the cost incurred by users, thereby making adoption more attractive. Home security and safety represents the second-largest segment with 36% share. It is also the slowest-growing segment and is expected to grow from $1.8B in 2015 to $6.3B by 2020 (29% CAGR), well below overall growth of 52% during the same timeframe. All other segments currently account for less than 5% of the consumer services market.

Exhibit 47: Consumer services TAM and mix ($B)

Consumer services TAM
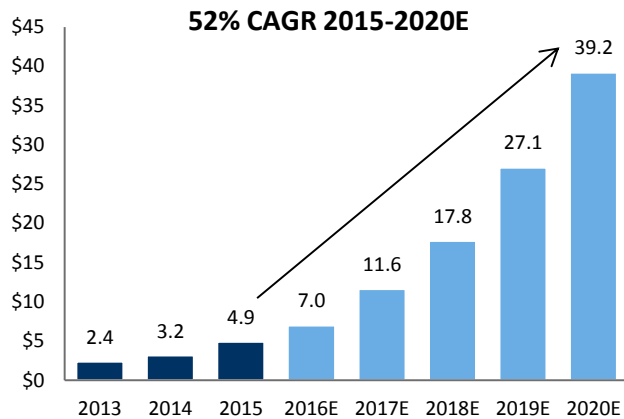
52% CAGR 2015-2020E

Year	Value
2013	2.4
2014	3.2
2015	4.9
2016E	7.0
2017E	11.6
2018E	17.8
2019E	27.1
2020E	39.2

Mix (2015)

- Automotive Infotainment 3%
- Home Auto., Energy Mgmt. 4%
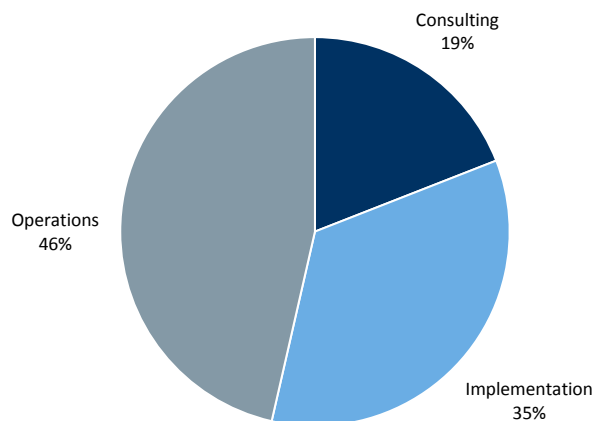- Home Security & Safety 36%
- Health & Fitness 57%

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

On a growth basis, information & entertainment and automotive infotainment are the two fastest-growing segments. The information & entertainment market is expected to expand from $16.7M in 2015 to $1.6B in 2020, representing a CAGR of 148%. The automotive infotainment market, which includes car entertainment, safety, navigation, communications, and maintenance services, is anticipated to expand from $128M to $7.9B in the same timeframe, representing a CAGR of 128%. While these two segments combined currently account for less than 10% of the overall consumer services market, they are expected to represent nearly one-quarter of the mix by 2020.

Exhibit 48: Information & entertainment and automotive infotainment services revenue ($M)

Information & entertainment

148% CAGR 2015-2020E

Year	Value
2013	4.8
2014	7.6
2015	16.7
2016E	53.8
2017E	164.7
2018E	408.6
2019E	864.2
2020E	1,580.2

Automotive infotainment

128% CAGR 2015-2020E

Year	Value
2013	29.6
2014	61.3
2015	127.5
2016E	461.5
2017E	1,192.0
2018E	2,586.8
2019E	4,872.3
2020E	7,922.5

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Professional IoT services

Professional services refer to spending on outsourced services over a project lifecycle that includes consulting, implementation, and ongoing operations. Professional services spending is driven by the enterprise's need to lower costs, increase efficiencies, and pursue new revenue opportunities in order to stay relevant in the ever-changing competitive landscape. The aggregate professional services market was $178B in 2015 and is on pace to hit $412B in 2020, representing a CAGR of 18%.

Exhibit 50: Professional IoT services spending by phases ($B)
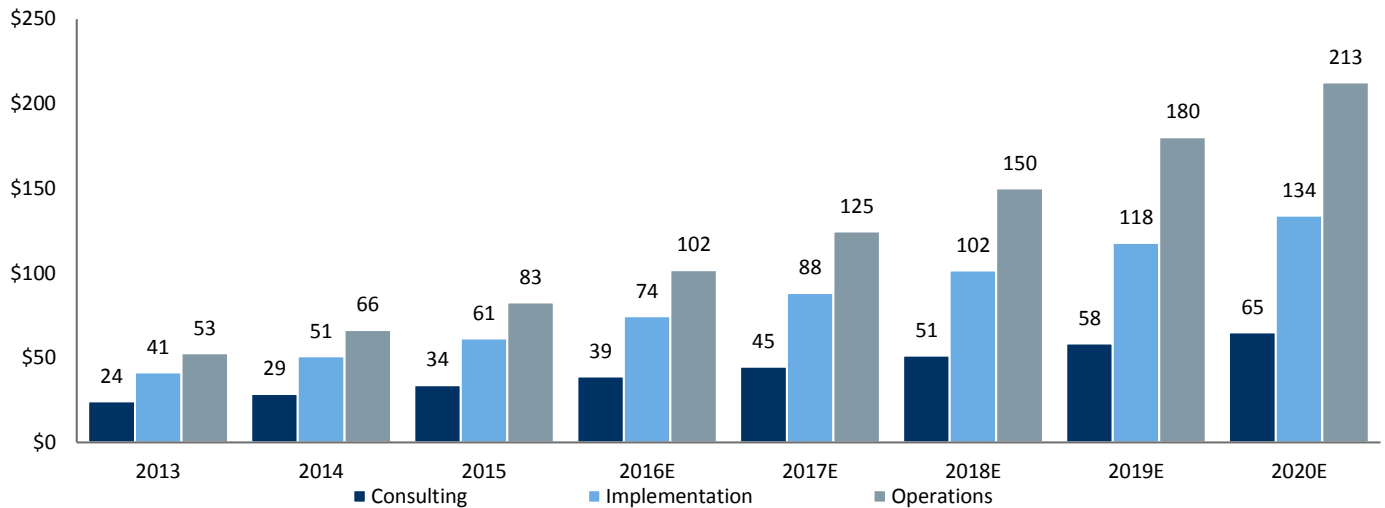
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

The professional services market is currently split as follows: consulting 19%, implementation 35%, and operations 46%. As the IoT installed base increases and IoT technology matures, we expect a mix shift to operations from consulting and implementation.

Looking at the verticals within professional services, we find that manufacturing & natural resources has the largest base at ~40% of the total market. The segment is driven by modernization of manufacturing infrastructure to connected instrumentation, control systems, and robotics. Manufacturing represents the bulk of the spending in this vertical, but natural resources represent the better growth opportunity as mining, agriculture, and construction are still in the early stages of IoT. Government (15%), utilities (14%), and transportation (13%) also represent more than 10% of the market due to heavy investments in military, smart meters, and fleet management over the past several years. While communications, retail & wholesale trade, and insurance only account for ~6% of the base in aggregate, they are the highest-growing verticals due to ample greenfield opportunities.

Exhibit 51: Professional services mix (2015)
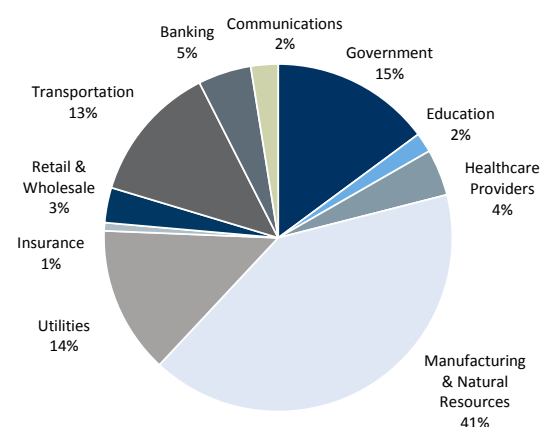
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Examining the major use cases

IoT is the latest technology trend with the potential to disrupt the market across all industries. While there are endless applications of IoT, we highlight the key uses cases that are driving the adoption.

Within the industrials sector, our RBC Multi-Industry analyst Deane Dray has highlighted General Electric (GE) as being well positioned to win in the sector's ongoing "gold rush" towards developing SaaS solutions for Industrial IoT applications. This is largely driven by GE's first-mover advantage in introducing its marquee Predix operating system, which will be marketed through its strategic partnerships with service providers like Accenture, Cisco, IBM, AT&T, Oracle, and Intel, among others. Though Digital only accounts for +$6 billion of GE revenues in 2016 (5% of total mix), the company expects this contribution to expand to $15 billion by 2020, implying a 25% CAGR. Finally, GE sizes the Industrial Internet addressable market at $225 billion by 2020, comprised of $125 billion in Applications and $100 billion in Platforms, on pace to exceed the Consumer Internet ($170 billion) and Enterprise ($200 billion), according to GE management.

Industrial IoT

While much of the hype and excitement surrounding IoT is centered on consumer applications such as connected cars, smart homes, and wearables, industrial IoT is driving a revolution that is dramatically shifting the way companies manufacture, transport, monitor, and troubleshoot their products. Industrial IoT is a subset of IoT that integrates physical machinery, facilities, and infrastructure with the network and analytics solutions. Industrial IoT solutions aim to reduce cost while maximizing operational efficiencies through the collection, aggregation, and analysis of data from sensors. The total market opportunity for industrial IoT is hard to size, because the market is extremely broad and industry experts apply differing definitions. Industry analysts have estimated the industrial IoT market ranging from $150B to over $10T.

A joint research by World Economic Forum and Accenture categorizes industrial IoT into four distinct phases. The first two phases focus primarily on the near-term opportunities, which include driving operational efficiency by enhancing asset utilization, cost reduction, and worker productivity (Phase 1). Phase 2 introduces new products and services to the market (typically subscription-based) that help enterprises capitalize on the data. Phase 3 is a longer-term target that requires structural changes and is likely to take longer for general adoption. Solutions will be more integrated, thereby creating an ecosystem of connected platforms. Finally, Phase 4 represents a pull-based economy characterized by continuous demand-sensing, resource optimization, waste reduction, and end-to-end production automation.

Exhibit 52: Four phases of industrial IoT
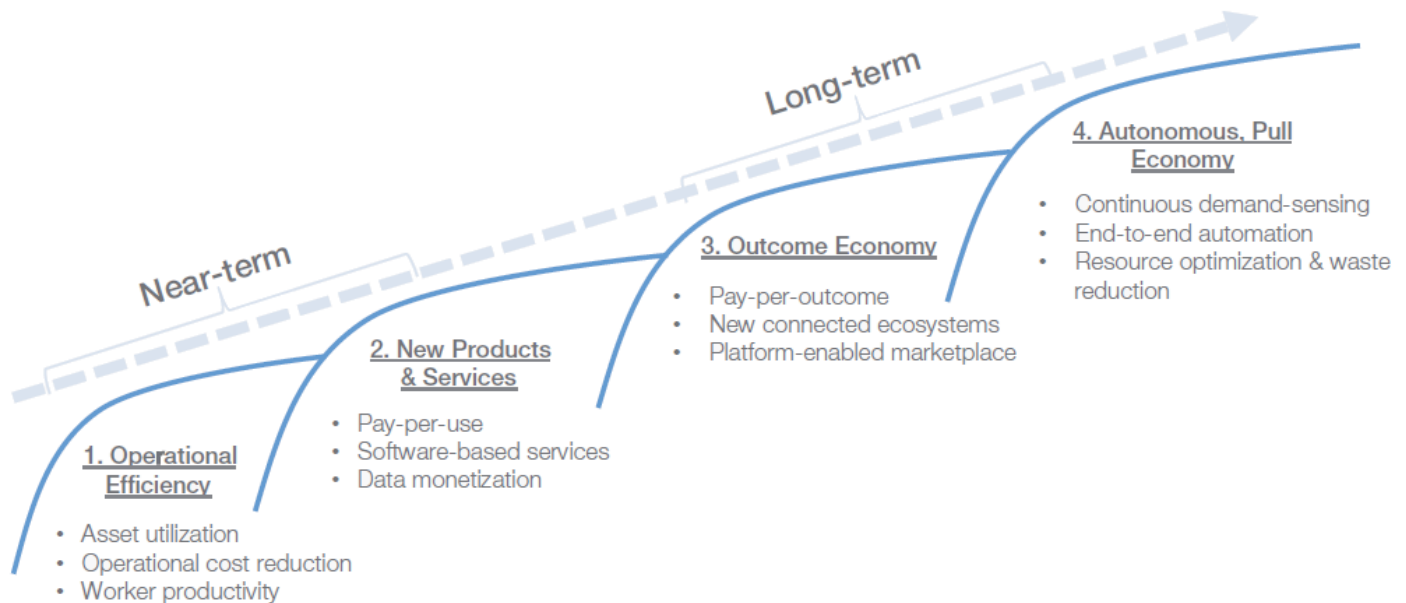
Source: World Economic Forum: Industrial Internet of Things: Unleashing the Potential of Connected Products and Services

Manufacturing

The manufacturing sector has seen early adoption of connected technology, using M2M communications and robots to automate many of the manual processes. However, most connected manufacturing plants today are on a closed network, confined to communicate only within the plant walls. Industrial IoT is a natural extension to M2M communications, which allow users from any location to interact with the manufacturing machinery and infrastructure in any facility. Key benefits that IoT brings to manufacturing include:

- **Connectivity and mobility:** IoT solutions extend existing equipment and enterprise resource planning (ERP)/manufacturing execution systems (MES) with connectivity, interoperability, and mobility that enable users to monitor and control manufacturing assets from anywhere in the world.

- **Connected supply chain:** Assets, including raw materials, inventory, and equipment can be easily tracked and monitored using embedded sensors. This helps optimize logistics, maintain optimal inventory levels, and prevent loss and/or theft. The system can also be configured to replenish a product on a machine-to-machine basis automatically when it detects low stock levels, thereby ensuring that materials do not create a bottleneck in the production line.

- **Operations intelligence:** Manufacturers have real-time visibility and access across heterogeneous systems, people, and assets in a single, unified platform, thereby enabling them to make faster and better decisions, and improve operational performance.

- **Unified key performance indicators:** Many industrial IoT solutions can aggregate data from isolated systems for analysis, which can be helpful in gaining high-level and actionable insights across multiple manufacturing systems. Manufacturers can use web-based or mobile applications that provide role-based views into key indicators, with the ability to drill down into correlated data to diagnose and address problems quickly.

- **Predictive and proactive maintenance:** Continuous and detailed monitoring of critical equipment conditions and operating parameters can minimize downtime and avoid potential equipment failures. Policies can be set up that automatically trigger alerts in case of failure.

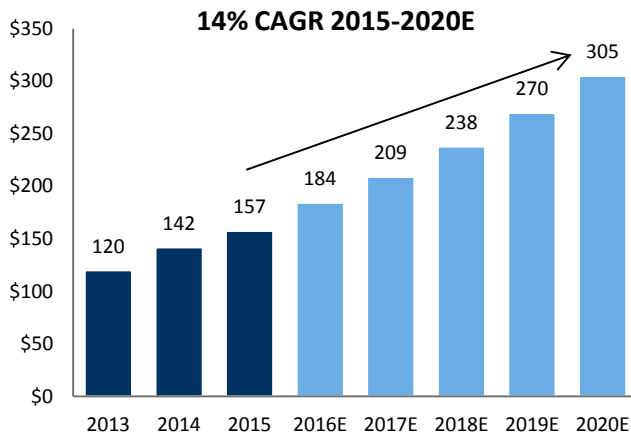Exhibit 53: Supply chain management and predictive analytics through industrial IoT
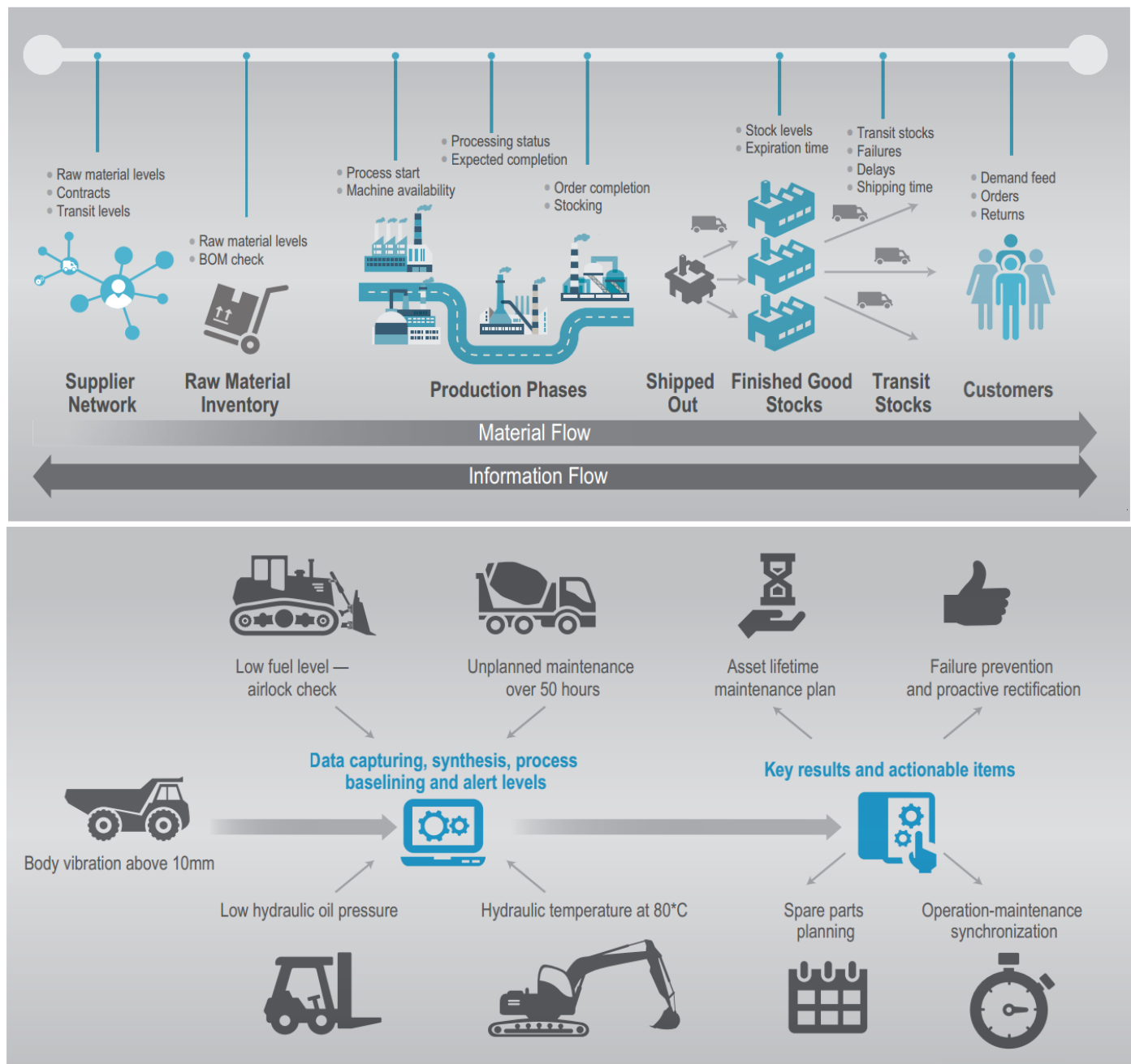

Source: Cognizant Technology Solutions

According to Gartner, the total TAM in the manufacturing sector, including services, was $157B in 2015. Total hardware spending was ~$84B (54% of total), while services was $73B (46% of total). The IoT-related manufacturing market is expected to grow at a 14% CAGR though 2020 to reach $305B, driven by stronger services revenue over time.

Exhibit 54: Manufacturing market opportunity

Manufacturing TAM ($B)
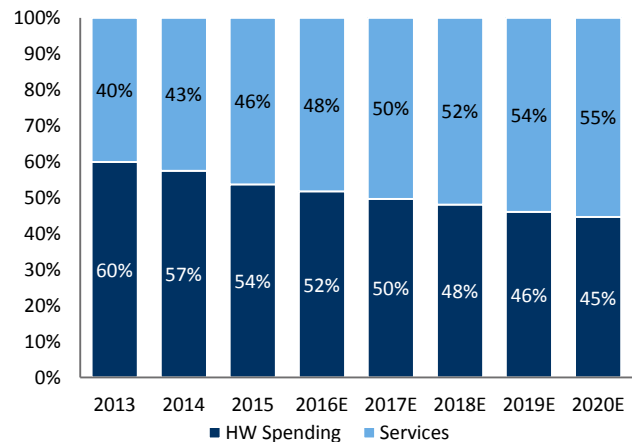
14% CAGR 2015-2020E

Revenue Mix

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Energy and utilities

Energy and utilities are heavily regulated industries, and IoT adoption has historically been driven by companies effectively pressed into modernizing their old infrastructure to meet regulatory compliance. In the US, for example, the Energy Act of 2007, which increased fuel economy requirements, accelerated the demand to monitor and track energy consumption. Subsequently, the American Recovery and Reinvestment Act of 2009 spurred the modernization of electrical grids.

IoT helps create an ecosystem where the companies have complete visibility to control every facet of energy delivery from plant assets and pipes to customer meters. All these components work in conjunction through the network to monitor energy consumption continuously across the entire power grid and ensure proper load balancing to optimize energy generation. Utility companies can also quickly identify areas of power attenuation and detect disruptions to address the problem and minimize outages quickly.

Enabling IoT technologies for the energy and utilities industry includes:

- **Smart grids:** Smart-grid devices include connected line sensors, regulator controls, switches, and energy-storage devices that communicate with the control systems. Intelligent networks of smart-grid components communicate with each other to share peak loads and monitor electric grid in real time. The sensors collect large volumes of data, including data on energy generation, power attenuation, leakage, and power consumption, which can be beneficial in diagnosing asset health and will likely lead to improved energy efficiencies, services, and customer engagement.
- **Smart meters:** Manual meter readings are both time consuming and expensive, as they require a technician to visit every site and record the usage data. Smart meters have two-way communication capabilities that monitor energy consumption. With smart meters, both energy providers and consumers have access to view power, gas, and water consumption in real time that enable better billing and demand forecast.

Exhibit 55: Smart grid and smart meter applications
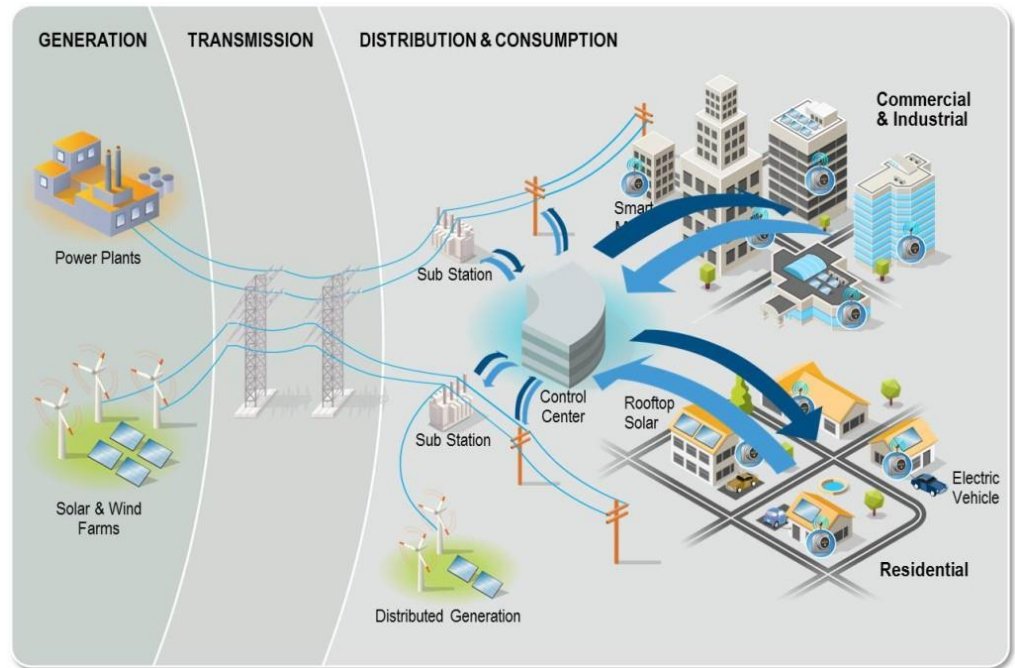

Source: Trilliant Holdings

The current IoT market for energy and utilities is $46B and is expected to reach $112B by 2020. Breaking down the revenues: hardware spending was $21B in 2015 and is expected to grow to $47B in 2020 (18% CAGR), while professional services is expected to grow from $24B to $62B (20% CAGR) and connectivity services for smart meters expected to grow from $1.0B to $3.4B (27% CAGR) during the same timeframe.

Exhibit 56: Energy & utilities market opportunity

Energy & utilities TAM ($B)
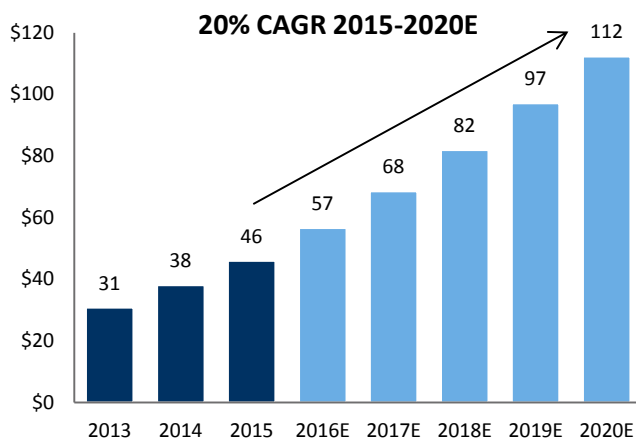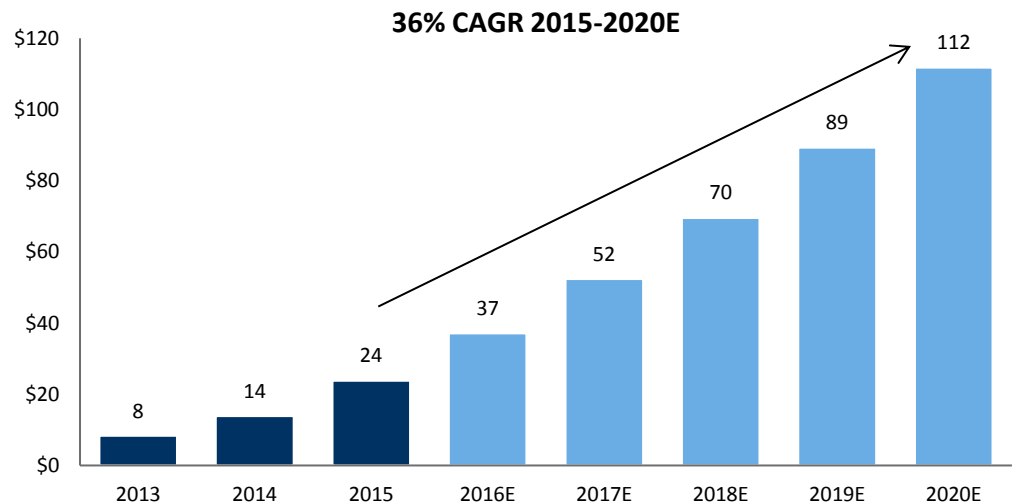

Revenue mix (2015)
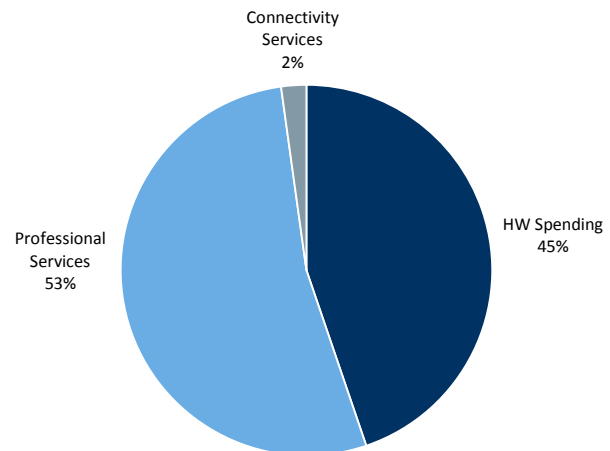
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Connected home

The connected home is one of the faster-growing segments of IoT, and Gartner estimates smart, connected homes will grow from 100–200M to 500–700M by 2020. There are three main constituents of connected homes: (1) home automation, (2) home energy management, and (3) home security. The total connected home market, including services, is expected to grow from $24B in 2015 to $112B in 2020.
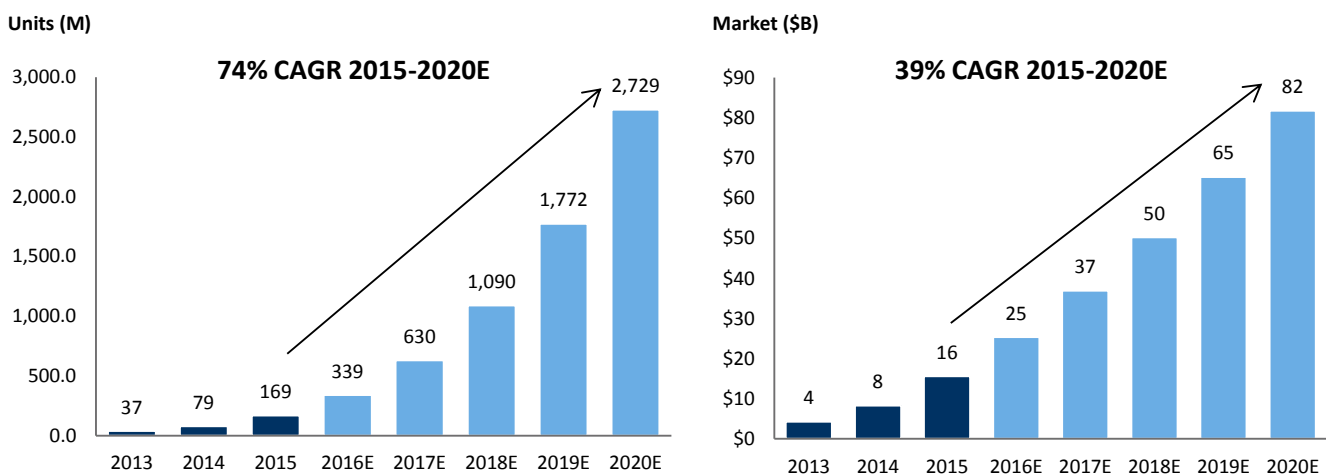
Exhibit 57: Connected home market ($B)

36% CAGR 2015-2020E

Year	Value
2013	8
2014	14
2015	24
2016E	37
2017E	52
2018E	70
2019E	89
2020E	112

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Home automation involves household items, including but not limited to lights, door locks, window shades, heating, ventilating, and air conditioning (HVAC) systems, kitchen appliances, entertainment systems, and virtual assistants that are connected to a network (usually to the homeowner's Wi-Fi). Portable devices such as smartphones and tablets act as gateways that the devices connect with, and enable users to monitor and control the devices under a single, unified platform. There was a total of ~169M home automation units in the market in 2015, which represented a $16B market in 2015. The number of connected units is expected to grow at a 74% CAGR to 2.7B units by 2020, while spending is anticipated to increase at 36% CAGR to $82B. We highlight a few products within home automation:

- **Philips Hue:** Philips Hue LED light bulbs grant complete control of lighting to end-users. Using their smartphones, users can schedule on-off times, change color/brightness, and even sync to music.
- **August Smart Lock:** With August Smart Lock, the user's mobile device becomes both a key and a command center. The smart lock automatically unlocks when it senses the homeowner at the door by using Bluetooth technology. Homeowners also have the ability to lock/unlock and grant virtual keys to guests using the mobile interface. The solution can be easily integrated with other connected home solutions including Apple HomeKit, Google Nest, and Honeywell Total Connect.
- **Google Nest Thermostat:** Nest is a thermostat that adapts to the user's lifestyle. The device captures data on: (1) the times the HVAC unit is turned on/off; (2) temperature preference; and (3) when the house is vacant to program itself automatically to operate in the most efficient manner. According to Park Associates, over 40% of all thermostats sold in the US were smart thermostats. Google also created the "Works with Nest" program to integrate third-party application with its products.

- **Amazon Echo:** Echo is a combined virtual assistant and speaker unit that can be controlled with voice. Echo not only provides hands-free voice control for music, but it also integrates with other third-party services and smart home hubs to: (1) pull information from the web; (2) purchase items online; and (3) control home lighting, entertainment systems, and other household appliances. Echo incorporates machine-learning technology and adapts to the user's speech patterns, vocabulary, and personal preferences.
- **Amazon Dash Button:** This simple Wi-Fi-powered device can place replenishment orders for household supplies (such as detergent, groceries, cosmetics, etc.) on Amazon.com with the push of a button.
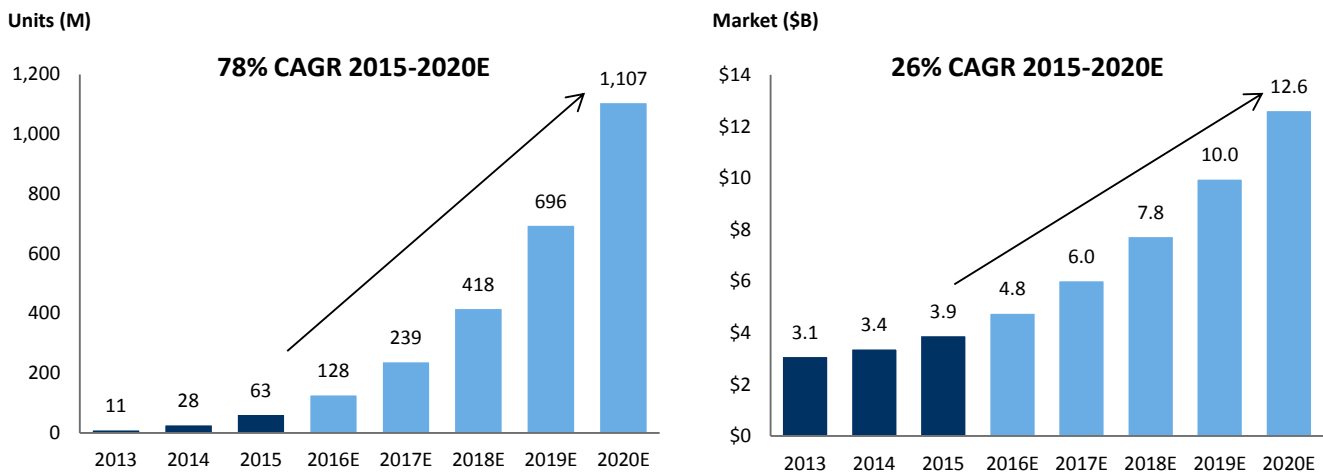
Exhibit 58: Home automation units and market size

Units (M)

74% CAGR 2015-2020E

2013	2014	2015	2016E	2017E	2018E	2019E	2020E
37	79	169	339	630	1,090	1,772	2,729

Market ($B)

39% CAGR 2015-2020E

2013	2014	2015	2016E	2017E	2018E	2019E	2020E
4	8	16	25	37	50	65	82

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Home energy management focuses primarily on managing power consumption levels. Smart meter devices can measure the time and location (outlets) of peak usage and relay this information to users to encourage more efficient energy consumption. Users can also turn off appliances remotely to conserve energy. Research by Park Associates showed that ~70% of US households with smart energy devices reduced their energy cost due to reduced energy consumption. While benefits are evident, we note that this segment has been lagging growth in home automation and home security segments. We believe this is due to consumers viewing energy as a commodity and not fully understanding the costs. In 2015, there were a total of ~63M home energy management units, which represented a $3.9B market. The number of connected units is expected to grow at a 78% CAGR to 1.1B units by 2020, while spending is anticipated to increase at a 26% CAGR to $13B.
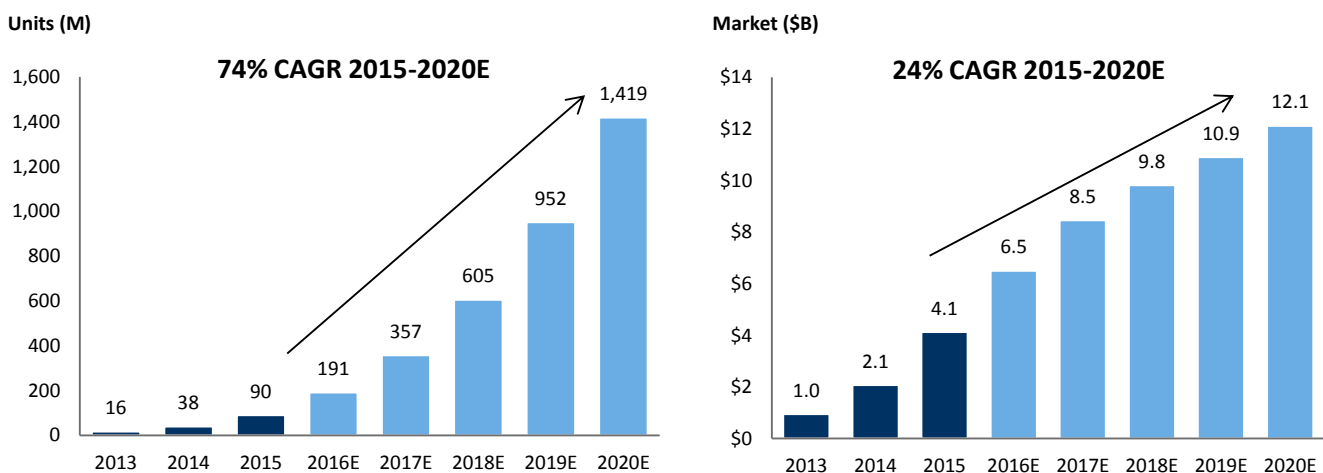
Exhibit 59: Home energy management units and market size

Units (M)

78% CAGR 2015-2020E

Year	Units
2013	11
2014	28
2015	63
2016E	128
2017E	239
2018E	418
2019E	696
2020E	1,107

Market ($B)

26% CAGR 2015-2020E

Year	Market
2013	3.1
2014	3.4
2015	3.9
2016E	4.8
2017E	6.0
2018E	7.8
2019E	10.0
2020E	12.6

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Home security is the last component of a smart home and includes burglar alarm control units, motion sensors, and security cameras. When motion is detected after arming the system, the security camera automatically records video and sends alerts to the homeowner and the authorities. In 2015, there were a total of ~90M home security units, which represented a $4.1B market. The number of connected units is expected to grow at a 74% CAGR to 1.4B units by 2020, while spending is anticipated to increase at 24% CAGR to $12B.

Exhibit 60: Home Security Units and Market Size

Units (M)

74% CAGR 2015-2020E

Year	Units
2013	16
2014	38
2015	90
2016E	191
2017E	357
2018E	605
2019E	952
2020E	1,419

Market ($B)

24% CAGR 2015-2020E

Year	Market
2013	1.0
2014	2.1
2015	4.1
2016E	6.5
2017E	8.5
2018E	9.8
2019E	10.9
2020E	12.1

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

In the connected home market, Google, Apple, and Samsung are leading the disruption with interoperability protocols and extensive ecosystems.

- **Samsung SmartThings** is an open ecosystem that comprises of a hub, motion sensor, multipurpose sensor, presence sensor, water leak sensor, and a smart outlet. The hub is the control center that communicates with all the smart devices, including third-party devices that have been certified by SmartThings. With the mobile app, users can monitor and control devices through the SmartThings cloud and create scenarios that trigger actions in the devices.

- **Nest Labs** is owned and operated by Alphabet (Google). The Nest Labs connected home ecosystem comprises three products: Nest Learning Thermostat, Nest Protect, and Nest Cam. Nest thermostat learns a user's temperature preferences to program itself and automatically turns off when nobody is home. Nest Cam is a security camera that automatically activates itself when the thermostat is set to away. Nest Protect is a smoke and carbon monoxide detector that alerts the user and communicates with the thermostat to turn the furnace off when carbon monoxide is detected. Google created an ecosystem of third-party development with the "Works with Nest" program and opened its Next Weave networking technology to third-party developers.
- **Apple HomeKit** provides a framework for the connected home. HomeKit works through an iOS app and allows connected devices inside the home, such as smart lights, speakers, thermostat, smoke detectors, outlets, and door locks, to communicate with each other. The HomeKit is also enabled with Siri, enabling voice-activated commands.

The rise of connected home technology carved a new opportunity for communications service providers (CSPs), as they can tap into their existing customer base. Most CSPs deploy third-party platforms, while some have created their own proprietary ecosystems, such as AT&T. AT&T Digital Life offers basic home security and automation services with optional safety and energy management packages (smoke/carbon monoxide detector, smart plugs, thermostat, and temperature and water sensors). Users control the connected devices and receive alerts with the Digital Life app on smartphones, tablets, or computers.

Exhibit 61: Connected home ecosystem

Vendor	Product	Product Range	Integration with 3rd Party Devices
Alphabet (Google)	Nest Labs	Learning thermostats; Security cameras; Smoke and carbon monoxide alarms	Amazon Echo Google Voice actions
Amazon	Echo	Smart hubs	
Apple	HomeKit	Smart hubs	
AT&T	Digital Life	Smart plugs; Motion sensors; Leak Sensors; Smoke sensors; Thermostats; Control Panels	Google Nest
Belkin International	WeMo	LED lighting; Smart switches; Webcams; Motion Sensors; Smart hubs	Amazon Echo
Deutsche Telekom	Qivicon	Home hubs	
D-Link	mydlink Home	Smart plugs; Motion sensors; Water sensors; Sirens; IP cameras; Home hubs	Amazon Echo
Icontrol Networks	Piper, Icontrol One, White Label	Home security cameras; Door/window sensors; Smart switches; Microsmart; Water leak sensors	
Samsung	SmartThings	Home hubs; Motion sensors; Smart outlets; Moisture sensors; Presence sensors; Multipurpose (door/window) sensors	Amazon Echo
Smartlabs	Insteon	Smart plugs; Motion sensors; Leak sensors; Smoke sensors; Thermostats; Remote controls; Smart hubs	Amazon Echo Apple HomeKit Google Nest
Vivint	Vivint Smart Home	Cameras; Smart locks; Smart thermostats; Cloud storage; Garage door controllers; Lighting & small appliance controls; Door and window sensors; Key fobs; Smoke, motion, carbon monoxide, flood/freeze and glass break sensors	Amazon Echo Google Nest
Weebee	Weebee Life	Smart plugs; Motion sensors; Temperature, humidity and pressure sensors; Smart hubs	Amazon Echo Google Nest

Source: Gartner Competitive Landscape: Connected Home Ecosystems, 2016, RBC Capital Markets

Connected car

The emergence of IoT has also massively transformed the automotive industry. Car manufacturers have traditionally been focused on optimizing the internal capabilities of vehicles such as improving fuel efficiency and safety features. Their attention has now shifted to enabling connectivity to the outside world, which brings new opportunities for the automotive industry including Vehicle-to-Infrastructure (V2I), Vehicle-to-Vehicle (V2V), Vehicle-to-Cloud (V2C), Vehicle-to-Pedestrian (V2P), and Vehicle-to-Everything (V2X). Gartner estimates that 80% of all new vehicles will have data connectivity by 2020, while 30% will have built-in, over-the-air software update capabilities.

Exhibit 62: Connected car services
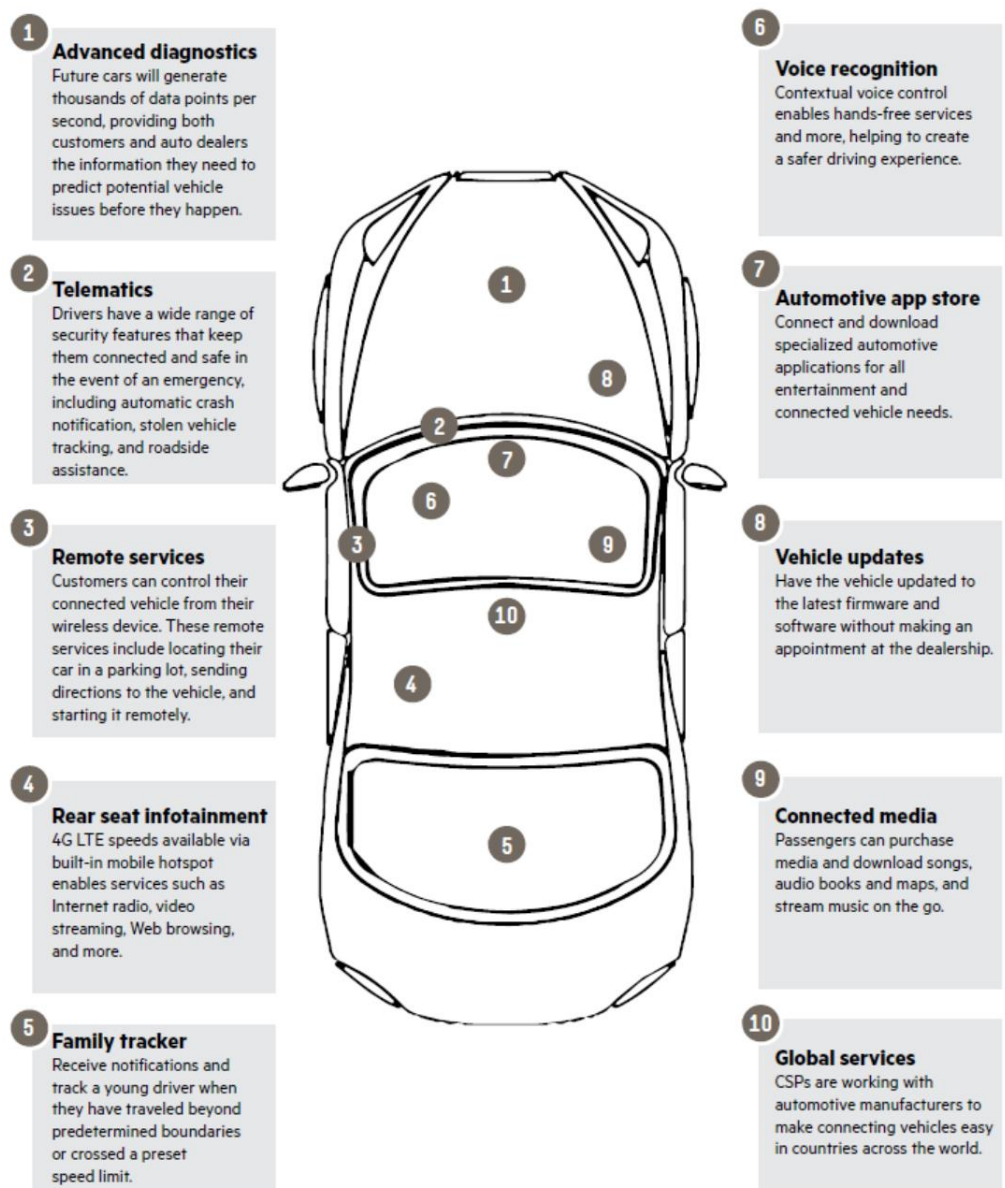
Source: Hewlett Packard Enterprise

Connected vehicles have the potential to enhance both in-car as well as out-of-car user experiences. Some examples of these services include:

In-car services

- **Infotainment:** Infotainment systems have evolved beyond being just a platform for music and video. More vehicles enable connectivity to smartphones that allow users to make phone calls, check email, use third-party apps, and access websites using the internal controls of the vehicle.
- **Navigation:** By connecting to traffic servers, the vehicle can pull live, real-time traffic alerts and road condition information, and direct the user to the most efficient route.
- **Communication/connectivity:** Some connected cars have embedded cellular modems that enable Wi-Fi for the passengers. The communication link can also be used for safety and security measures to notify the authorities automatically when it detects a collision or a break-in. In addition, connectivity enables over-the-air updates for vehicle software without having to visit the dealership.

Out-of-car services

- **Remote services:** Cars that are equipped with global positing satellite (GPS) sensors can be tracked using a mobile device, which can be particularly useful when tracking a stolen vehicle. Using a mobile app, users can also control a car's minor functions such as locking and unlocking doors and turning on the ignition.
- **Telematics:** Connected vehicles present new opportunities for businesses. For example, OnStar provides emergency assistance and automatic collision notification, and telecom companies such as AT&T provide mobile Wi-Fi hotspots in vehicles. Additional opportunities involve services related to traffic advisory, fuel management, driving diagnostics, etc.

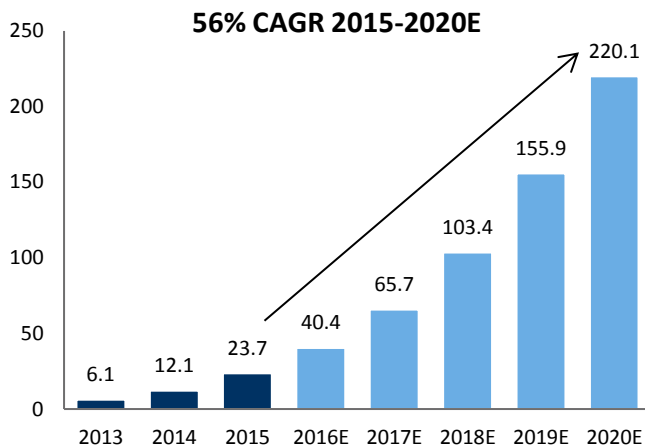Exhibit 63: In-car and out-of-car services

Source: Delta Partners Group

Gartner defines the segment both as a single entity (the vehicle in its entirety) and as a collection of subsystems (body, chassis, infotainment, etc.). Using Gartner's estimates, the number of connected cars was ~24M in 2015 and is expected to reach ~220M by 2020, increasing at a CAGR of 56%. There are ~15 electronic subsystems in a connected vehicle on average, with "body" subsystems (climate control, security, seat, lighting, and other electronic control units) making up ~38% of the total electronics content. Infotainment and safety also represent more than 10% of the mix at 14% and 13%, respectively. Notably, while advanced driver assistance systems (ADAS) make up only 2% of the component mix, it is the fastest-growing segment due to the growing interest in driver-less, self-driving cars. ADAS is expected to grow at a 70% CAGR from 5.9M units in 2015 to 83.5M units in 2020.

Exhibit 64: Connected car units and mix

Connected car units (M)　　　　　　　　　　　　　　　　　　　　**Subsystem mix (2015)**
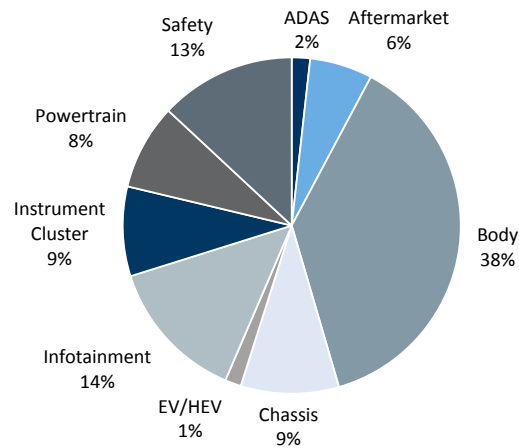
Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Similar trends appear in terms of shipments. Body, infotainment, and safety represent the three largest subsystems, while ADAS is the fastest-growing sub-segment. The total connected car shipment was ~12M in 2015, and the unit shipment is expected to increase to ~65M units by 2020.

For automotive and component manufacturers, the connected car segment represents a $338B market opportunity as of 2015. It is also one the faster-growing segment in terms of consumer and business spending. Gartner estimates the market for connected cars will reach $1.5T in 2020, representing a five-year CAGR of 35%.

Exhibit 65: Connected car spending ($B)

35% CAGR 2015-2020E

Year	Value
2013	94.2
2014	179.1
2015	337.7
2016E	466.9
2017E	675.0
2018E	968.7
2019E	1,291.5
2020E	1,520.6

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Health and fitness

The healthcare industry is shifting toward a more data-centric model, and IoT is at the crux of the transformation, helping healthcare providers improve operational efficiency and patient care. For example, IoT solutions can help hospitals operate better through a dynamic management of their assets. New software patches can be pushed to the connected medical devices automatically, and remote diagnosis can be performed on devices to ensure correct operation. In addition, RFID technology can optimize inventory levels and auto-replenish the products in low stock.

A network of IoT-enabled devices also permits doctors to have up-to-date patient medical records at all times. This makes redundant the practice of different doctors performing the same examination on a patient, instead reallocating time and resources into focusing on a patient's current problems. The patient data can also be made portable, allowing physicians to retrieve medical records on their mobile devices to address any questions or concerns raised by a patient. Total spending by healthcare providers is estimated at ~$12B and is expected to increase at a 16% CAGR to ~$26B in 2020.

Exhibit 66: Healthcare provider spending ($B)

16% CAGR 2015-2020E

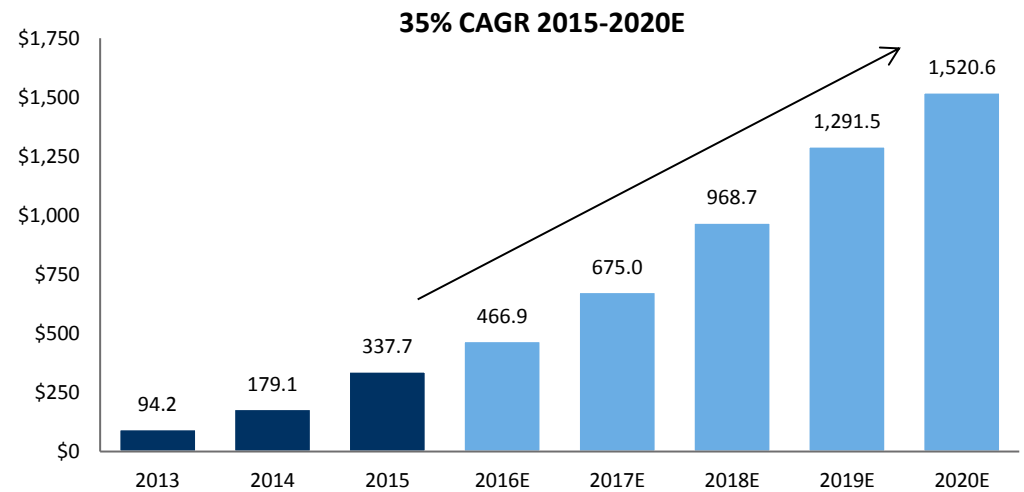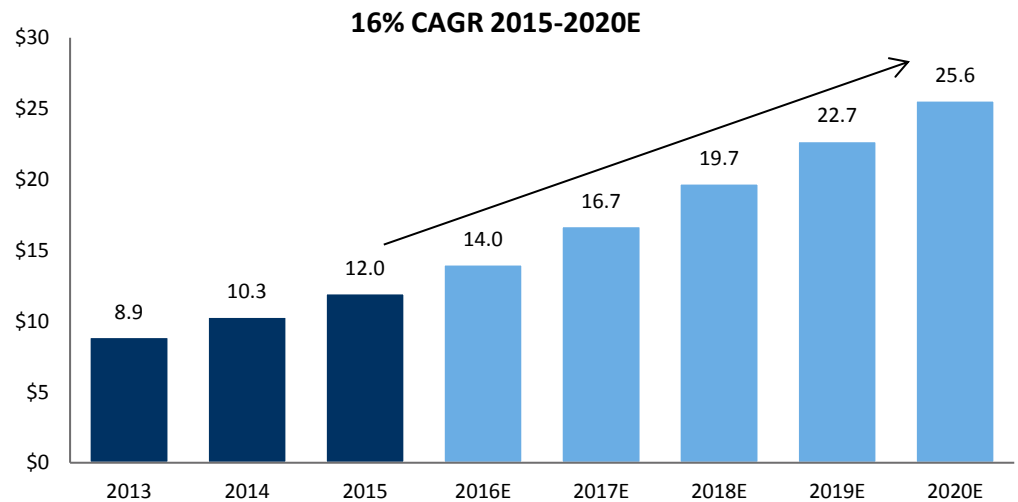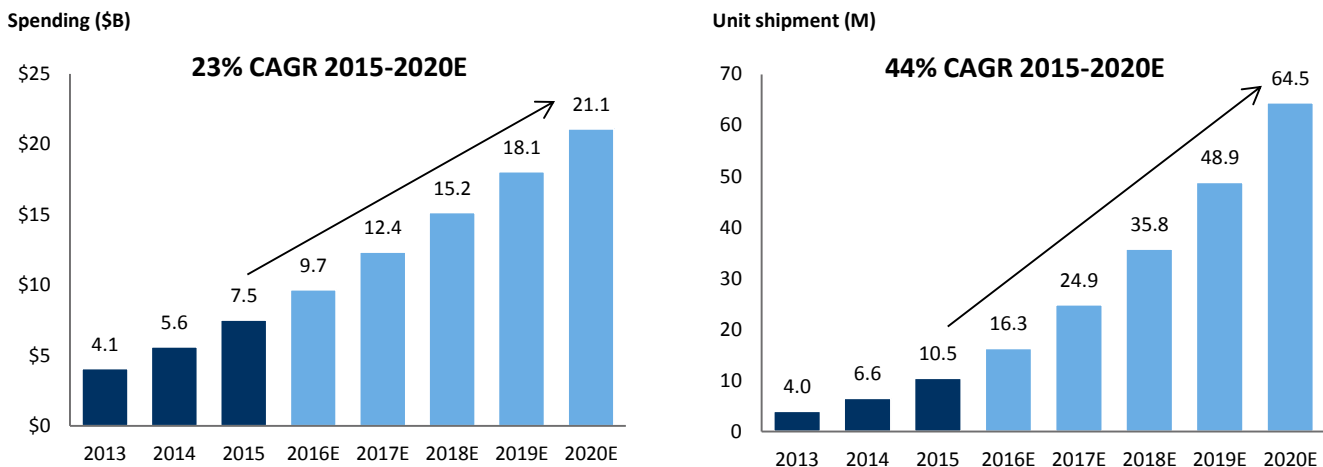|	2013	2014	2015	2016E	2017E	2018E	2019E	2020E
	8.9	10.3	12.0	14.0	16.7	19.7	22.7	25.6

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

On the consumer side, increased health awareness, integration of data to healthcare providers, and fast-growing corporate wellness programs have fuelled the growth of medical monitoring devices and fitness trackers. Medical devices examine the patient's vitals, including blood pressure, glucose level, and heart rate, and then alerts the medical facilities when vitals drop to dangerous levels. Users can also leverage the data to take necessary preventative measures. We estimate total spending on medical devices at $7.5B increasing to ~$21B by 2020. During the same timeframe, we expect shipments to grow at a 44% CAGR, from 11M units in 2015 to 65M units in 2020.

Exhibit 67: Medical monitoring device spending and shipments

Spending ($B)

23% CAGR 2015-2020E

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E
	4.1	5.6	7.5	9.7	12.4	15.2	18.1	21.1

Unit shipment (M)

44% CAGR 2015-2020E

	2013	2014	2015	2016E	2017E	2018E	2019E	2020E
	4.0	6.6	10.5	16.3	24.9	35.8	48.9	64.5

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Fitness wearables track the user's activity metrics such as heart rate, steps, distance traveled, and calories burned. A key driver for fitness trackers is visibility into the user's fitness and activity level, coupled with an expanded use case of sleep monitoring and location tracking. Fitness trackers remain widely popular with an install base of 174M, which is expected to exceed 310M by 2020 (15% CAGR). However, the market for fitness wearables may see a slight deceleration due to: (1) the market becoming saturated; (2) falling ASPs; and (3) stiffer

competition from smart watch vendors (e.g., Apple). The fitness wearable market was $9.5B in 2015 and is expected to grow at a 9% CAGR to $14.4B by 2020. Wrist appears to be the preferred form factor as wristbands and smart watches make up ~60% of the installed base.

Exhibit 68: Fitness wearable spending and mix

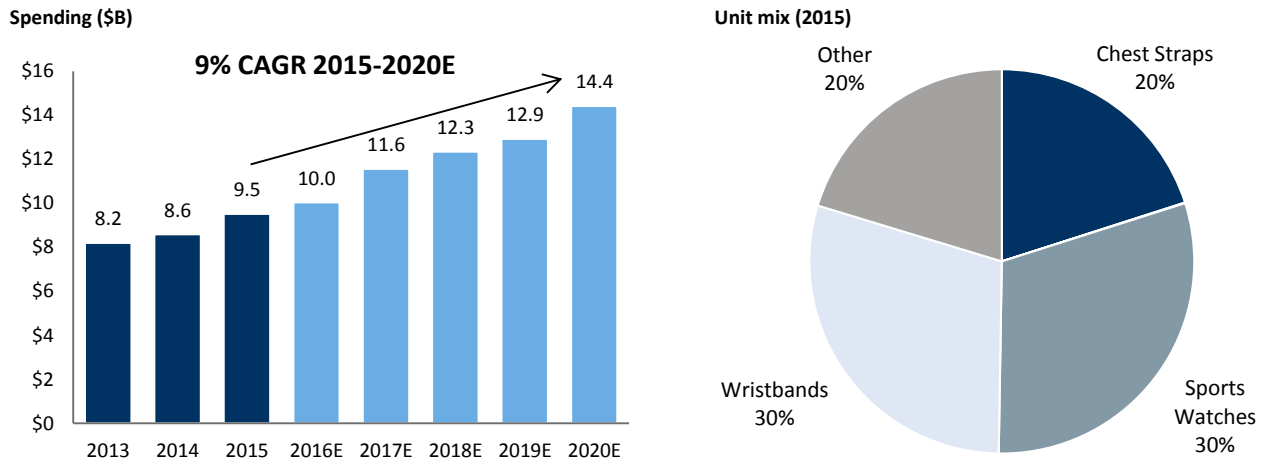**Spending ($B)**

9% CAGR 2015-2020E

Unit mix (2015)

Source: Gartner Forecast: Internet of Things - Endpoints and Associated Services, Worldwide, 2015 by Peter Middleton et al., RBC Capital Markets

Platform-based IoT

Cisco: As a de facto standard in networking, Cisco seeks to leverage its expertise and intellectual property in connectivity to capture market share. The company has aggressively ramped its IoT platform, evidenced by its $1.4B acquisition of Jasper Technologies in March 2016. The cloud-based Jasper Control Center optimizes the IoT service lifecycle by providing automated, real-time visibility and control over connected devices, networks, and applications. Jasper's solution complements Cisco's native IoT services such as security, advanced analytics, and enterprise Wi-Fi. With over 3,500 customers and 25 IoT Service Providers using the Jasper platform, we expect Cisco to become a forerunner in IoT. Notably, a survey conducted by ZK Research indicated that people associate Cisco as the leader in IoT.

Exhibit 69: Survey: Which vendor do you associate most with IoT?
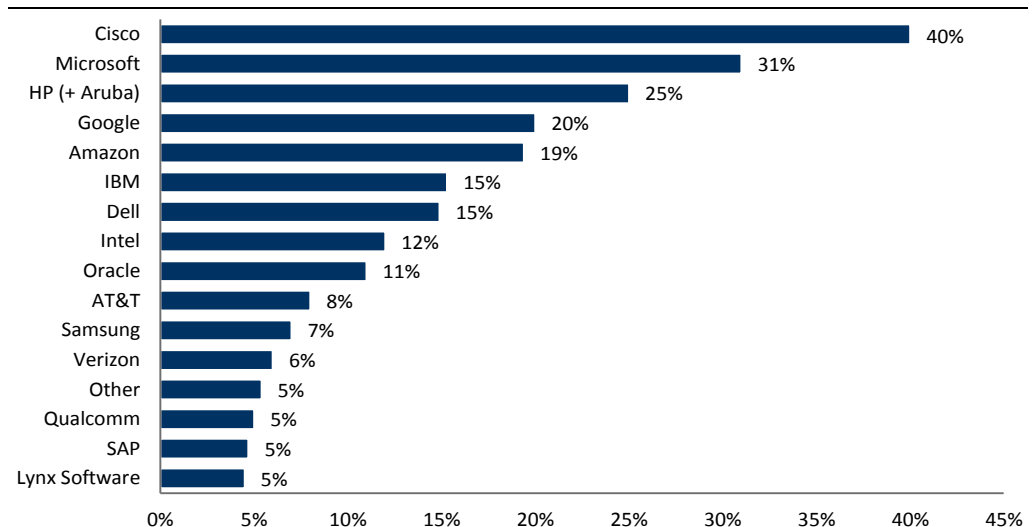
Source: ZK Research, RBC Capital Markets

Microsoft: Microsoft Azure IoT Suite provides enterprise-grade services to collect data from devices, analyze data streams in real time, store and query large data sets, and integrate with back-office systems. Microsoft offers an end-to-end turnkey solution with preconfigured Azure services, but enterprises can also customize configuration using Azure SDK to meet specific IoT needs. Azure preconfigured services include:

- Azure IoT Hub is a gateway that enables communication among devices and provides device-to-cloud and cloud-to-device messaging capabilities.
- Azure Stream Analytics aggregates sensor data and provides in-motion data analysis.
- Azure Storage utilizes DocumentDB to store device metadata, which is used to perform device management analysis.
- Azure Web Apps and Microsoft Power BI provide analytics tool to create visualizations and interactive dashboards to discover new business insights.

HP Enterprise: The company launched the HPE Universal IoT Platform in May 2016, which is industry, client, and vendor-agnostic, and complies with the one M2M standard. HPE's IoT platform: (1) communicates with connected devices over disparate networks; (2) aggregates data from multiple heterogeneous systems into a single cloud platform; (3) integrates the information with external data sources to develop contextual data; and (4) leverages HPE Vertica and HPE Haven OnDemand to discover new business insights. The platform supports numerous connectivity standards, including cellular, radio, Wi-Fi, and Bluetooth, as well as

long-range, low-power connectivity, LoRa and SIGFOX deployments. Through its networking arm, Aruba, HPE also provides sensors and Wi-Fi equipment for IoT. Aruba sensors combine Wi-Fi client and Bluetooth low energy (BLE) radio in a small form factor, which can be embedded in any device to enable location-based services and data analytics.

Google: With the $3.2B acquisition of Nest Labs in 2014, Google became a significant player in the IoT market, providing standalone products such as smart thermostats, carbon monoxide/smoke detectors, and security cameras. Google has now shifted its focus to adopting a platform-based approach, offering various IoT services (storage, networking, monitoring, analytics, machine learning, security, etc.) through its Google Cloud Platform. At the core of the platform is Brillo and Weave. Brillo is an Android-based IoT operating system for embedded development that is compatible across ARM, x86, and MIPS-based hardware. Brillo has a built-in security framework and offers analytics, Weave integration, and over-the-air (OTA) update capabilities. Weave provides a standardized way to enable discovery, provisioning, and authentication of the devices and supports communication between the devices and cloud services.

Amazon: Amazon has recently gained much publicity with the launch of its Dash Replenishment Service and Amazon Echo that we described earlier. However, the company is also making waves in the enterprise space with AWS IoT-managed cloud service, which launched in October 2015. AWS IoT offers a scalable solution to connect endpoint devices securely with the cloud applications. One big benefit of the platform is integration with the powerful AWS services such as AWS Lambda, Amazon Kinesis, Amazon S3, Amazon Machine Learning, Amazon DynamoDB, Amazon CloudWatch, AWS CloudTrail, and Amazon Elasticsearch Service. These solutions allow users easily to collect, process, analyze, and gain actionable insights on data. Key components of AWS IoT include:

- Device Gateway allows devices to communicate with AWS IoT securely, and scales automatically to support over a billion devices without provisioning infrastructure.
- Authentication and Authorization enhance secure data transfer between the device and AWS IoT by authenticating and encrypting data at all points of connection.
- Registry assigns a unique identifier for each device and tracks metadata information.
- Device Shadows create a persistent, virtual version of each device, enabling applications and other devices to interact with the "shadow" during intermittent connections. Using the AWS IoT API or a rules engine, users can retrieve the last reported state of a device or set a desired future state.
- Rules Engine automatically transforms device messages based on user-specified rules to AWS services without having to manage any infrastructure.

IBM: The company is heavily focused on IoT and has aggressively invested in the space in recent years. IBM introduced its Internet of Things Foundation in October 2014 and in March 2015 announced plans to invest over $3B in the following four years to form a dedicated IoT business unit. IBM's IoT platform is powered by Watson, the company's cognitive computing service and Bluemix, a cloud-based application platform. Bluemix provides a set of APIs that communicate with and access data on connected devices. Watson acts as a central hub gathering all the data and leverages its machine learning and predictive analytics capabilities to deliver real-time insights to the users.

Intel: Intel's IoT Platform provides a secure, scalable, and interoperable end-to-end reference architecture model that works across both Intel and third-party solutions to connect devices and deliver customer value. The company also offers a low-power, low-cost processor, Quark, which is prevalent in connected devices across the automotive, energy, healthcare, industrial, and retail industries. IoT is one of the fastest-growing operating

segment within the company, generating revenues of $572M in the Jun-16 quarter. While the segment only accounts for ~5% of Intel's revenues, we expect it to accelerate in the coming years.

Exhibit 70: Intel's IoT platform
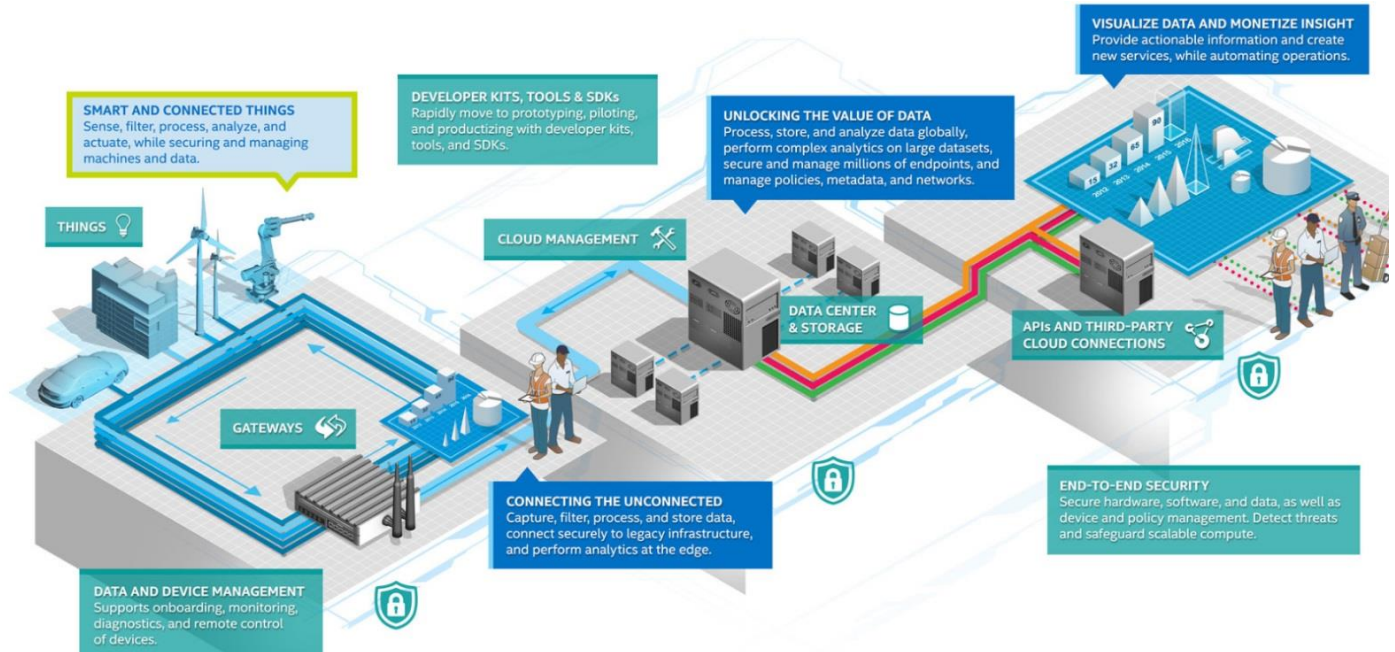
Source: Company reports

Edge IoT: This category consists of hardware components and equipment such as sensors, actuators, gateways, and memory chips. In our view, the key products for Intel in this category are its Gateway solutions, Wind River Edge, McAfee Embedded Control, Intel Atom processor, and Intel Quark processor.

Exhibit 71: Intel's Edge IoT products

Product	Features
Wind River Edge Management System	• Can connect devices in a broad variety of markets • Connectivity agent pre-integrated with local OS to ensure a streamlined out-of-box experience • Efficiently transfers sensor data to remote server securely • Scalable on-demand infrastructure with SSL encryption • Data and message-processing capabilities • Pre-integrated application development support
IoT Gateway with EMS	• Enables connectivity up to the cloud and enterprises and down to sensors and existing controllers embedded in the system. • Pre-process filtering of selected data for delivery. • Enables easy connectivity to legacy systems. • Local computing for in-device analytics.
McAfee Embedded Control	• Enables application whitelisting: shields applications at the kernel level, preventing malware exploits • Minimizes the need for continuous application or OS patching • Change control: Enables policy based authorized changes. Monitors files and prevents unexpected changes and logged for compliance • Centralized management through McAfee ePolicy Orchestrator
Intel Atom	• SoC designed specifically for intelligent systems • Extended thermal range • High I/O connectivity, integrated memory controller • Virtualization, error correcting code (ECC), and built-in security • Energy efficient
Intel Quark	• Has fine-grained power management features that enable battery powered and line-powered sensors to provide secure, intelligent processing for wired and wireless real-world applications at the edge. • Includes an integrated sensor hub that keeps power to a minimum by intelligently handling and processing data from external sensors. • Includes security features to protect against malicious intrusions • Features extended temperature with ranges from -40 °C to +85 °C - ideal for small form factor IoT applications.

Source: Company reports

Data center endpoints: This category includes data center processors, security, storage, and analytics software components that interact with the end hardware.

Exhibit 72: Intel's data center and analytics products for IoT

Product	Features
Intel Xeon Processors	• With large memory capacities, it can provides real time analytics on large data sets in seconds or minutes • Enables to run mission-critical workloads with 99.999% up time. • Provides reliability and serviceability features through Intel Run Sure Technology • Improved virtualization and low latency • Scalable memory for optimization with 8+ socket configurations available • Includes hardware assisted technologies that protect data and accelerates encryption • Higher I/O bandwidth to increase performance
Intel Omni-Path	• Adaptive Routing: Monitors the performance of the possible paths between fabric end-points and chooses the least congested path • Dispersive routing: distributes traffic across multiple paths driving fabric efficiency • Packet Integrity protection: Allows for rapid and transparent recovery of transmission errors • Dynamic Lane Scaling: allows an operation to continue even if one or more lanes of a 4x link fail
Intel solid state drive	• Handles 2.3x more transactions with Intel's chipsets, firmware and drivers • Improved performance with Intel's NVMe technology • Can cache frequently accessed data enabling server applications to run faster • Uses Intel's leading edge memory technology for data center storage
Cache accelerator software	• Improves storage I/O bottleneck. Caches hot data to improve workload performance, without the need for external storage. • Enables hot data retrieval when needed • Up to 12x performance compared to an HDD-only storage solution • Up to 75% lower latency and 70% reduced recovery time compared to HDD only solutions
Intel solutions for Lustre Software	• Fully parallel I/O throughput across 1000s of clients, servers and storage devices • Scalable to 1000s of clients and petabytes of data • Hardware, server and network fabric neutral • Integrated support for Hadoop* MapReduce* applications with Lustre* storage

Source: Company reports

Software and services: This includes the API management, data as a service, and services orchestration that interact with the data centers.

Exhibit 73: Intel's software and services products for IoT

Product	Features
Intel Mashery API Management	• Includes powerful routing, transformation and choreography tools for API creation • Enforces API security, access control and operational policies with cloud or hybrid gateways • Provides analytics for deeper insights into API programs
IoT Services Orchestration	• Intuitive graphical programming in HTML5 IDE • Great compatibility with runtime scripting and abstraction to infrastructures • Supports wide range of IoT use cases with advanced features like multiple In/OuT graphic node, configurable data acceptance

Source: Company reports

Wearables: This includes key components and technology such as Wi-Fi, LTE, BLE, and RFID that go into the end-consumer devices such as watches, and health and fitness products.

Exhibit 74: Intel's products for wearables

Product	Features
Intel Developer Kit Edison	• Provides an open source software development environment • Contains high performance dual core CPU that supports complex data collection at low power • Integrated Wi-Fi and Bluetooth 4.0 with 1GB DDR and 4GB flash memory • Includes 40 multiplexed GPIO interfaces with expansion board options
Intel Curie	• Low power solution of the size of a button, designed for wearable devices • Ideal for always on applications such as social media and fitness activities • Includes a 6 axis combo sensor with accelerometers, gyroscopes and Bluetooth low energy • Comes with 384kb flash and 80kb SRAM • 32-bit Intel Quark SOC runs on a coin-sized battery
MICA	• 1.6 inch OLED touchscreen display • Enables creating a VIP contact list and custom quick replies • Time-to-go technology that notifies wearer when it is time to leave • Supports 48 hours of battery life • Includes a sim card slot for unfettered connectivity
Basis Peak	• Automatically tracks sleep duration, toss and turns and provides a sleep score to help understand sleep patterns • Includes 4 sensors (optical heart rate engineer, 3-axis accelerometer, Skin temperature and Galvanic skin response) for 24/7 insights • Adjusts weekly fitness goals based on your performance • Helps answer or decline calls at 1 click. Review messages and read email notifications directly from the watch

Source: Company reports

External collaboration: Intel also collaborates with external IoT platform vendors to integrate with its products to provide a complete end-to-end solution. In this regard, Intel works with Cloudera, an enterprise analytic data management software vendor powered by Apache Hadoop with data center architecture powered by Intel Xeon technology. On the Wearables side, Intel collaborates with fitness companies such as New Balance, Oakley, TAGHeuer, and Fossil to come up with innovative wearable devices using Intel's technological expertise on the device, analytics, and software fronts.

Component-based IoT

Analog Devices: Analog Devices offer a broad range of IoT connectivity and sensing devices such as low-cost RF switches and temperature sensors. Recently acquired SNAP Sensor enhances ADI's optical sensor technology and may strengthen its position in the connected home (security cameras, smart appliances) and autonomous vehicles market.

Impinj: Impinj is a RAIN RFID solutions provider that offers wireless connectivity for everyday items and delivers intelligence information to organizations and consumer applications. The company's platform comprises software, hardware, and application interfaces that assign a unique identity to each item and enables inventory management, patient safety, asset tracking, and item authentication. Impinj's product portfolio provides a foundation for the IoT.

Maxim Integrated: Maxim offers the building blocks to create connected products in the automotive, industrial, wearable, and energy segments. Product portfolio includes: (1) sensor ICs for temperature, pressure, and optical that can be used in home/factory automation; (2) RF transceivers for connectivity; (3) heart rate, blood oxygen, and electrocardiogram sensors for wearables; and (4) energy meter SoCs for smart meters.

Microsemi: Microsemi primarily builds products for industrial markets such as aerospace and defense in addition to providing solutions for communications and data center markets. Microsemi specifically focuses on security at a component level for IoT applications. It includes security into every step of its silicon manufacturing process. Microsemi uses physical unclonable function (analogous to human fingerprint) and passive/active anti-tamper techniques built into the chips for security. IoT products for Microsemi are primarily in the switches and the field-programmable gate array (FPGA) space.

Exhibit 75: Microsemi products for IoT

Product	Features
SmartFusion2 SoC	• Includes an ARM Cortex-M3 processor with embedded flash • Very low power: reduced power by 20-40% • Provides protection from overbuilding and cloning • Includes secure boot for FPGA & Processors • Reliable and safe for mission critical systems
1G/10G Ethernet PHYs	• Helps reduce development costs and time to market • Features VeriTime, industry's defacto for accuracy • 256/128-bit AES encryption enabled Industry's only secure 1588 ICs able to support AES encryption without compromising 1588 timing accuracy

Source: Company reports

NVIDIA: NVIDIA entered the autonomous vehicle market with the Drive CX and Drive PX, based on the Tegra X1 chipset. Drive CX is a digital cockpit technology, and PX is a platform for self-driving cars. At CES 2016, the company announced NVIDIA Drive PX 2, which utilizes deep learning for 360-degree situational awareness and determines the optimal path for safe travel.

Qualcomm: Qualcomm has leveraged its low-power, high-performance Snapdragon processers as a launch pad into IoT. The company has seen recent success, shipping over 1B devices powered by Qualcomm technology. It is also pushing aggressively into the wearable market with a dedicated chip, the Snapdragon Wear 1100 processor, which offers a next-gen Cat 1 modem with LTE/3G global band support, as well as support for voice, Wi-Fi, and Bluetooth connectivity. Qualcomm also developed the 2net platform that collects health information from various medical devices and health applications for analysis. Another tailwind for the company is the number of IoT patents. According to LexInnova, it is the largest patent holder with 724 patents.

Exhibit 76: Top IoT patent holders (2016)
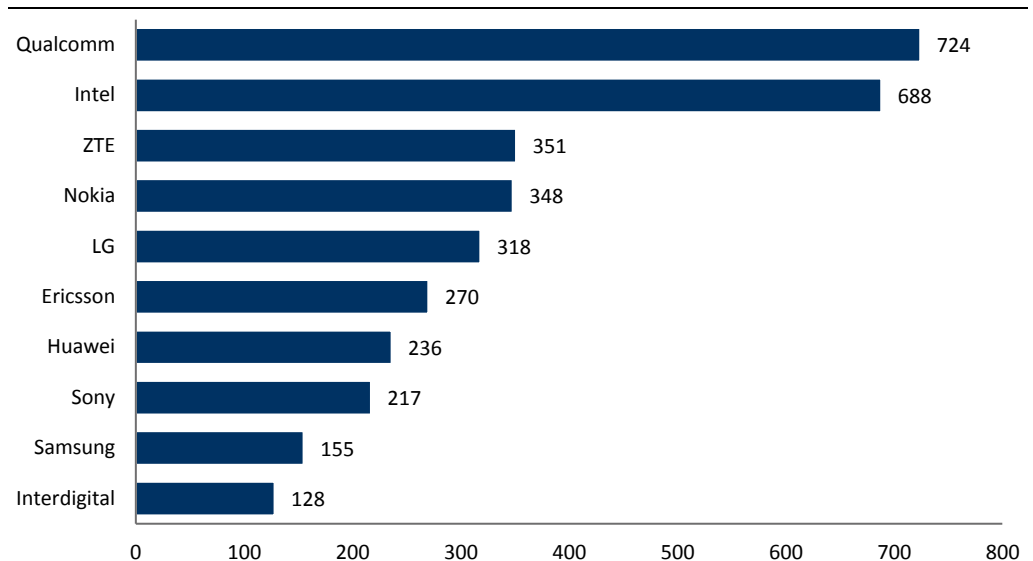
Source: LexInnova, RBC Capital Markets

Semtech: Semtech's LoRa RF platform extends the reach of IoT by enabling low data rate wireless communication transmissions over a long distance (up to 15km), with a battery life of greater than 10 years. The LoRa platform simplifies deployment and lowers costs by eliminating the need for repeaters. Applications for LoRaWAN include metering, security, asset tracking, and other M2M applications.

Sensata: Sensata offers a wide range of automotive sensors, including fuel, temperature, humidity, pressure, position, and vision sensors that can be used in vehicles to improve safety and efficiency.

TE Connectivity: TE Connectivity manufactures connectivity components applied to a wide range of wireless devices including smartphones, wearables, smart utility meters, and security systems. The company also offers various sensors, which can be used in connected car and home automation solutions such as temperature, humidity, speed, pressure, and water-level sensors.

Texas Instruments: TI offers a broad range of microcontrollers, processors, sensors, and wireless connectivity chips for IoT. TI's product portfolio can be used for various IoT applications, including home automation, smart manufacturing, health and fitness monitoring, and connected cars.

Software enablers

In a vertical model, companies offer the full breadth of IoT products, from IoT devices and gateways to the cloud-based services. Advantages of such a model are evident: full compatibility across the IoT chain, single point of contact for support, and potential cost-savings as companies can source materials cheaper. However, having a full-stack solution is infeasible for most vendors because it requires high expertise in networking, cloud, and analytics, and is highly capital intensive. From a customer perspective, the downside of a vertically integrated solution is dependence on one vendor for enhancements, and a breach in one system might compromise the entire network.

As a result, there has been a natural transition to a horizontal model. The horizontal model promotes faster innovation, as vendors can concentrate on their strengths, while relying on partners for peripheral solutions. Two main horizontal solutions are analytics and building-block platforms. Analytics solutions provide advanced business intelligence (BI) capabilities that can be used to uncover new business insights to improve efficiencies and save costs, while building-block solutions provide frameworks to design, build, and deploy IoT and M2M solutions. We highlight several companies from each segment below:

Analytics

Tableau: Tableau is a leader in next-generation BI, offering easy-to-use and powerful visualization tools to make sense of large volumes of data. Tableau combines data from multiple sources seamlessly and uses an intuitive drag-and-drop feature to enable any user—even those without extensive data warehousing knowledge—to create dynamic reports and dashboards and gain key insights into the business. Tableau offers four versions of its namesake product.

- **Tableau Desktop:** Provides the platform for users to create visualizations and analyze data in depth.
- **Tableau Server:** A sharing platform where visualizations created in Desktop are shared with other users on the server for collaboration and to speed up decision-making.
- **Tableau Online:** A hosted version of Tableau Server. Users can access data and visualizations anywhere via a mobile device or a web browser.
- **Tableau Public:** A free, cloud-based offering used to create and publish dashboards on public data.

ColdLight: A data analytics platform owned and operated by PTC. It works in conjunction with PTC's ThingWorx IoT Platform to detect patterns in data gathered from connected devices. ColdLight's machine learning and predictive analytics capabilities are especially useful in service and product lifecycle management, as the platform can be used to detect the performance of each sensor in the field and notify the agents when a component is nearing a failure, thereby improving product and service uptimes.

Splunk: Splunk provides an analytical platform for real-time operational intelligence, and enables organizations to search, monitor, analyze, and visualize machine-generated data from websites, applications, servers, networks, sensors, and mobile devices. Splunk software and cloud services deepen business and customer insights, mitigate cyber-security risks, improve service performance, and reduce costs. Splunk offers four core products:

- **Splunk Enterprise:** The company's flagship product with collection, indexing, search, reporting, analysis, alerting, monitoring, and data management capabilities. Splunk Enterprise aggregates and indexes data irrespective of format and source, and enables users to run queries without having to define or understand the structure of the data

prior to collection. The software delivers visibility across the corporate environment and provides visualizations for business insights.

- **Splunk Cloud:** A cloud-hosted version of Splunk Enterprise, based on the AWS platform. Splunk Cloud is backed by a 100% uptime SLA and scales to over 10TB/day.
- **Splunk Light:** Provides a comprehensive solution for SMBs that do not need to index large volumes of data. Splunk Light is priced for small IT environments and uses a single-server solution to collect, index, and analyze customer machine data.
- **Hunk:** A Splunk analytics solution for Hadoop that has native support for major Hadoop distributions such as Apache Hadoop, Amazon EMR, Cloudera CDH, Hortonworks, and IBM InfoSphere BigInsights. Hunk includes a full-featured analytics stack and leverages the company's schema-on-the-fly and machine-data fabric technologies to reduce the typical integration and deployment effort required for Hadoop projects.

Wind River: Acquired by Intel in 2009, Wind River provides embedded real-time operating systems (RTOS) for small devices. Wind River's middleware solutions help organizations build intelligent connected products and systems that are scalable and conform to connectivity standards and networking protocols.

ParStream: Cisco boosted its analytics capability on the edge with the acquisition of ParStream in October 2015. ParStream's database technology is optimized for IoT, enabling organizations to compute and analyze large amounts of data at the edge in real time, with minimal infrastructure and operating costs. By performing the bulk of the analysis at the edge, less bandwidth is required since minimal communication is required between the devices and the cloud. This becomes increasingly important as more sensors and equipment are deployed.

Exhibit 77: Analytics platforms

Source: Company reports, RBC Capital Markets

Building blocks (platforms)

Mesh Systems: Mesh Systems provides software and services to help enterprises design, build, and deploy turnkey IoT systems, from hardware to networking frameworks. The company's MESHVista cloud platform leverages Microsoft Azure to connect, monitor, analyze, and control remote devices and machines. MESHVista includes:

- **MESHVista Smart Cloud:** Smart Cloud is a platform that combines data ingestion, business rule logic, data storage, data retrieval, data visualization, and enterprise integration capabilities into a unified smart system.
- **MV Agent:** The solution transforms devices into smart products. MV Agents are embedded into objects and work in conjunction with MV Connect to transport data across both wired and wireless networks.
- **MV Connect:** MV Connect allows secure and reliable connectivity into the MESHVista Smart Cloud via wireless or wired networks.

2lemetry: Acquired by Amazon in March 2015, 2lemetry is an IoT platform that integrates data from connected devices across the enterprise. The vendor-agnostic tool accommodates most legacy protocols commonly used in the industrial sector. 2lemetry's highly scalable ThingFabric cloud device supports high-data throughput, collects machine-data, and acts on it with rule engines and complex event processing.

PTC (ThingWorx, Axeda): ThingWorx IoT platform provides a collection of tools to allow organizations to create and deploy their IoT foundation easily and quickly. ThingWorx simplifies the development of IoT applications and connects the devices to related systems under a single platform, and has a built-in analytics engine. Axeda is a cloud-based connectivity service that provides remote device monitoring and management services. Axeda Machine Cloud services include:

- **Axeda Connect:** Communication software that connects devices to the cloud and then processes, transforms, organizes, and stores machine and sensor data.
- **Axeda Build:** An IoT application platform that simplifies development and enables rapid implementation of IoT applications.
- **Axeda Manage:** A web-based device management platform that enables users to monitor, manage, service, and control wired and wireless connected products and assets remotely.

SeeControl: Autodesk entered into the IoT market with the acquisition of SeeControl in August 2015. SeeControl is a no-code, cloud-based, enterprise IoT platform that connects, analyzes, controls, and manages remote devices. With SeeControl, manufacturers can analyze data and build algorithms using drag-and-drop modules and gain a better understanding of their product's use, thereby leading to improved product lifecycles.

Jasper: Jasper (acquired by Cisco) is a cloud-based software platform for the IoT. It is the largest IoT software service platform in the market. It helps manage, launch, and monetize IoT services, all on a single platform. Jasper highlights that the real value of IoT is not in the devices themselves but in the services that they enable and the new, often recurring, sources of revenue that those services generate. Jasper helps businesses bring their IoT solutions to customers faster with a readily usable and scalable platform. It enables businesses with the ability to have real-time visibility and monitor the status of their devices from any place 24/7. Since Jasper integrates platforms from carriers across the globe, businesses can expand at a much faster rate and start capitalizing on new revenue opportunities without worrying about platform compatibility. Jasper's IoT platform also includes automation, which can optimize

performance on the fly and lower operational costs and provide uninterrupted services and exceptional customer experiences.

Exhibit 78: Building block platforms

Source: Company reports, RBC Capital Markets

Private IoT Companies

Ayla Networks

Ayla Networks offers a comprehensive set of platforms for connectivity, application development and analytics to manufacturers developing IoT products. Its end-to-end software runs across devices, cloud and applications providing secure connectivity and data analytics both for B2B and B2C partners.

The Ayla IoT platform consists of embedded agents, cloud services and application libraries to help manufacturers manage, provision and analyze their Internet of Things deployments. Using Ayla's platform eliminates the need to invest in network stack development, security and cloud infrastructure.

Ayla's Agile Mobile Application Platform (AMAP) enables manufacturers and application developers to quickly provide their end users with mobile apps that are optimized to control their IoT devices. With an already built-in framework on top of application program interfaces (APIs), manufacturers can personalize and differentiate their products with only a minimal specification of their product's functionality.

Ayla's analytics platform provides an easy and affordable path for manufacturers to quickly visualize, analyze and explore their data without spending time and developmental resources to produce reports needed to help with product development and customer satisfaction.

Teezle

Teezle is a cloud-based IoT platform that provides an infrastructure for application enablement and service management to customers so that they can focus on their IoT applications. Teezle helps connect the different functional units with an organization to help gain real-time visibility and operational efficiency. It helps seamlessly integrate existing systems with third-party IoT platforms by leveraging pre-built TMatics modules. Teezle has 40 IoT applications deployed to its customers that manage over 70 different types of devices across 15 different industry sectors.

Relayr

Relayr is a cloud-based IoT platform that enables companies to quickly develop, test and bring their products to market, all within one business quarter. It allows companies to build connectivity between any service, sensor, software or hardware through its multi-protocol support and API adaptors. Founded in 2013, Relayr is a part of a global partner program based on enterprise middleware for industrial IoT and its platform is used across a wide range of industry sectors such as Smart Cities, Building Infrastructure management and Smart Appliances.

The key benefits of the Relayr platform are in Security, Latency and Scalability. It uses Transport Layer Security (TLS) for secure device communication and its data transmission executions are within 50ms. Relayr's DevOps clustering structure enables you to spin out extra instances as needed which allows for easy scalability. Relayr's API adapters enable enterprises to communicate between their own public or private cloud without using Relayr's cloud solution. And Relayr's analytics tools provide unlimited access to a company's device history and reports in multiple easy to consume formats. Lastly, Relayr's developer tools have fully featured RESTful APIs and real-time data channels that enable easy access to developers working to quickly get their applications up and running.

Electric Imp

Electric Imp provides a fully integrated IoT connectivity platform across hardware, software, OS, APIs, cloud services and security, enabling enterprises to focus instead on their product development and bringing their products to market at a faster pace. The Imp platform with its tools in business development, manufacturing and marketing helps build new partnerships, improve customer acquisition rates and reduce overall costs.

While the impModule, impOS and impCloud help with the hardware integration and cloud connectivity, imp Open API enables businesses to enhance messaging and monitoring applications. Imp IDE and imp IDE production tools help maintain the software and gain insights into the factory production lines. The other tools such as impSecure and impScalabiltiy help create secure and scalable applications across millions of devices.

Electric Imp platforms serve across several industrial segments such as Appliances, Smart building, Commercial equipment and Health & Fitness. Since the Electric Imp platform seamlessly integrates with industry-leading companies, it has established partnerships with the top firms in the cloud, enterprise applications, product design and hardware technology spaces.

Machineshop

Machineshop is primarily a data and device management IoT company over the cloud. Its cloud software is designed to run either on Machineshop's own cloud or on the customer's public, private or hybrid clouds. Its cloud is deployed using Amazon Web Services and is managed 24/7 for uninterrupted service.

Machineshop Edge is its services product primarily designed for Original Equipment Manufacturers to run sophisticated data services in closed environments with limited access to the internet. It includes an API-based platform that runs on small footprint embedded devices and provides computing capabilities without the need to interact with the cloud. For device management, Machineshop also offers Device IQ, a cross-platform product which helps to simplify, accelerate and cost-reduce the deployment and management of connected devices by leveraging its Edge and Cloud computing technologies. On the services side, the company offers data-collection services through a set of granular RESTful APIs to enable communication with a variety of IoT devices and database systems.

Machineshop also partners with independent software vendors and large technology companies such as Cisco, Dell, Qualcomm, Google and Salesforce to extend the value of its intellectual property and create a powerful ecosystem.

Axiros

Axiros is an IoT solution provider that allows customers to monitor and interact with devices in real time. In addition, the IoT software & services help manage the product portfolio to reduce handling requirements as well.

Server Products:
- AXESS is the company's flagship product for management of CPEs with Broadband Forum-compliant CWMP (TR-069) stacks and other protocols.
- AXTRACT is a transparent monitoring solution designed to gather high-volume diagnostic load without the need to pass it through a productive 3rd-party ACS.
- AXPERIENCE gives service providers the ability to offer improved products around Metering, HVCA, Lighting, Audio / Video and Security.

- AX.DHCP server is a clusterable carrier-grade DHCP / IPAM (IP Address Management) solution that can be integrated within given provisioning platforms.
- AX.INTEROP is the Axiros test platform that supports the Broadband Forum BBF.069 CPE Certification program.

Client Side Software Products:

- AX.ACT CWMP Client is used to provide TR-069 functionality to a variety of devices.
- Axact.Home is a suite of applications that allows end users to configure and manage their home devices on the LAN side of their networks.

Cloud Software:

- AXESS.CLOUD is an as-a-service Device Management solution, access to carrier grade TR-069 ACS management system.

Glue Software:

- AXPAND changes CWMP remote procedure calls and parameters into proprietary command flows and runs them on connected devices via non TR-069 protocols in a scalable way.
- Alarm Management: logging, monitoring, alarming and comprehensive analysis of complex distributed systems.

Exosite

The company's Murano product helps connect products with a platform integrated with easy-to-use APIs and integrated tools for IoT functionality. The product allows for large-volume connected product deployments that are secure and scalable.

Key Features Include

- *Device Management:* Built-in support to manage device status, deploy firmware updates, and control versioning.
- *Device Connectivity & Security:* A device connectivity layer that enables developers to quickly connect devices and communicate data over encrypted connections using industry-standard TLS protocol.
- *Device Provisioning:* A scalable, secure provisioning interface that provides the flexibility OEMs need to adapt to the manufacturing and in-field provisioning needs of individual applications.
- *Open Access:* Designed to be compatible with almost any embedded hardware configuration, regardless of the constraints of a device's onboard capabilities.
- *Dashboard Builder:* Quickly build, configure, and deploy dashboards to visualize device data. Easily set up viewing access per permission rights.
- *Embedded SDK:* The ExositeReady Embedded SDK provides developers with a quality embedded port to some of the most common Wi-Fi- and Ethernet-based embedded platforms.
- *Gateway Engine:* Exosite's Gateway Engine framework includes functionality like auto-provisioning, device management, in-field firmware updates, and more to expedite gateway design.
- *Development Libraries:* Open-source libraries for C, C++, Python, Java, .NET, Node, Go, and more to help jumpstart development.
- *Flexible Data Schemes:* Develop, maintain, and update complex data schemes that are based on device metadata, data sources, device groups, access policies, processing elements, events, and alerts.

Enlighted

Enlighted is an IoT company focused on products for the commercial real estate space. It creates sensor and gateway products that enable energy efficiency, space planning and HVAC optimization. Its energy manager product helps analyze data from its sensors on energy usage, occupancy and environment. The energy manager enables customers to create secure profiles for their lighting control systems and also facilitates integration with third-party automation systems for optimized performance. Its home automation product, Room Control, provides a browser interface that includes all the functions of a standard wall switch, with override control capabilities, all without additional wiring.

Enlighted products are used even in the Education and Healthcare industries for energy optimization. These institutions use Enlighted products to reduce the cost of building operations through its smart IoT building applications. Enlighted's smart sensors help with better lighting and its data analytics platform helps with decreasing maintenance costs, thereby helping these institutions save big on operational costs and improved staff productivity.

Enlighted partners with several Luminaire OEMs, electrical contractors and resellers to further innovate in the energy management space for commercial real estate industry.

M&A activity

Recent history suggests that small, independent IoT vendors struggle to gain widespread adoption and turn to global vendors (and their large customer base) to extend their reach. Theses independent vendors either form strategic partnerships or look for an opportunistic buyer. The large enterprises also benefit in that they can integrate next-generation technology with their existing solutions to target the $1.4T market. Over the past eight years, the number of IoT-related M&A transaction has grown exponentially from nine deals in 2008 to over 80 deals in 2015. We note that the number of transactions has picked up materially in the past two years, suggesting to us that companies are investing in IoT in full force.

Notable transactions: Within our current coverage universe, we note the following key recent transactions:

- **SoftBank/ARM:** On July 18, 2016, SoftBank announced plans to acquire the UK-based chip provider, ARM Holdings, for ~$32B (Softbank will pay £17 per ARM share or ~$22.50). ARM provides processor designs for mobile devices and currently powers more than 95% of smartphones. ARM's technology is used in Qualcomm, NVIDIA, Apple, and Samsung chips. ARM has started to shift its focus to designing chips in the networking industry (15% market share) and expects ~45% market share by 2020.
- **Cypress/Broadcom:** On April 28, 2016, Cypress Semiconductor announced that it would acquire Broadcom's Wireless IoT business in an all-cash transaction valued at $550M. Cypress will acquire BRCM's Wi-Fi, Bluetooth, and Zigbee IoT product lines and IP, along with its WICED brand and developer ecosystem. The business employs 430 people and generated $189M in revenue LTM. Cypress believes that the acquisition strengthens Cypress's position in embedded system markets such as auto/industrial, and establishes it as a leader in high-growth consumer IoT including wearable and home automation solutions.
- **Intel/Arynga:** Wind River, a subsidiary of Intel, acquired Arynga on April 4, 2016 for an undisclosed amount. Arynga provides over-the-air update software for automotive solutions, including both software-over-the-air and firmware-over-the-air update technologies. Wind River plans to expand Arynga's technology beyond the automotive industry and into IoT opportunities, providing OTA updates for the smart, connected devices.
- **Cisco/Jasper:** In March 2016, Cisco completed the acquisition of Jasper, an IoT services platform company, paying $1.4B in cash and equity awards and retention. Overall, Cisco views IoT as a large market opportunity, and Jasper has disrupted the market with more than 3,500 enterprise customers offered through more than 25 service providers and customers available in 100 countries.
- **IBM/The Weather Company:** On January 29, 2016, IBM completed the acquisition of The Weather Company's B2B, mobile, and cloud-based assets, including Weather.com, Weather Underground, WSI, and The Weather Company brand. Weather data from the acquisition will be linked with the Watson IoT platform for predictive analytics, which can provide valuable information to all industries heavily affected by weather. For instance, retail stores could proactively stock winter gear ahead of an expected snow storm, and utility companies could predict power outages based on weather forecasts.

Exhibit 79: Number of IoT M&A deals (2008–2015)
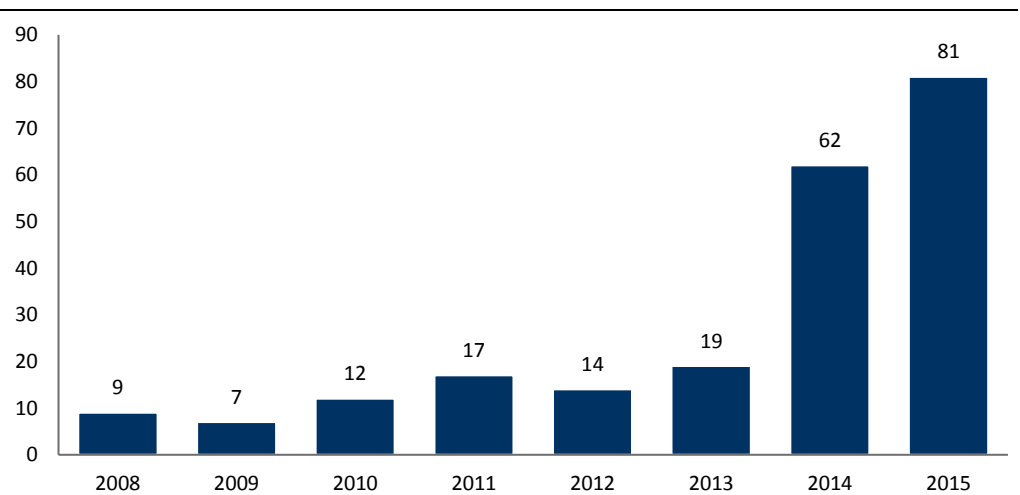
Source: 451 Research, Strategy Analytics, RBC Capital Markets

From a valuation perspective, we note the following average multiples paid on IoT transactions: EV/revenue basis: 6.5x LTM EV/rev and 5.6x FTM EV/rev; EV/EBITDA basis: 24.0x LTM EV/EBITDA and 20.1x FTM EV/EBITDA.

Exhibit 80: Select IoT transactions (2014 to present, $M)

Announce Date / Close Date	Acquiror / Target	Transaction Values		Enterprise Value /			Transaction Type
		Per Share	Enterprise Value	LTM Revenue	FTM Revenue	LTM EBITDA	
07/18/16 Pending	Softbank / ARM	£17.0	£23,233.6	22.8x	19.1x	42.8x	Cash
	Global chip provider for IoT devices, mostly in smartphones						
06/02/16 Pending	Thoma Bravo / Qlik Technologies	$30.50	$2,504.5	4.0x	3.4x	46.2x	Cash
	Next generation BI and data visualization software						
05/18/16	ARM / Apical	N/A	$350.0	21.1x	N/A	N/A	Cash
	Imaging and embedded computer vision intellectual property (IP) products						
04/28/16 07/05/16	Cypress Semiconductor / Broadcom	N/A	$550.0	2.9x	N/A	N/A	Cash
	Broadcom's Wi-Fi, Bluetooth, and Zigbee IoT product lines and IP, along with its WICED brand and developer ecosystem						
04/26/16 06/01/16	Nokia / Withings	N/A	€ 170.0	N/A	N/A	N/A	Cash
	Consumer wearable devices to track health and wellness						
04/04/16	Intel (Wind River) / Arynga	N/A	N/A	N/A	N/A	N/A	Cash
	OTA update software for automotive solutions, including both software-over-the-air and firmware-over-the-air update technologies						
02/03/16 03/22/16	Cisco / Jasper Technologies	N/A	$1,400.0	10.0x	N/A	N/A	Cash
	Cloud-based IoT service platform for enterprises and service providers						
01/05/16 03/11/16	Harman / Towersec	N/A	$70.0	N/A	N/A	N/A	Cash
	Global automotive cyber security company specializing in network protection for connected vehicles.						
10/28/15 01/29/16	IBM / Weather Company	N/A	N/A	N/A	N/A	N/A	Cash
	Personalized and actionable weather data and insights to consumers businesses						
06/23/15 09/02/15	Sierra Wireless / MobiquiThings	N/A	€ 14.0	4.7x	N/A	N/A	Cash + Contingent Pmt
	MVNO focused on managed connectivity services for the Internet of Things						
06/01/15 07/30/15	ARM / Sansa Security	N/A	$85.0	N/A	N/A	N/A	Cash
	Hardware security IP and software for advanced system-on-chip components deployed in Internet of Things and mobile devices						
06/01/15 12/28/15	Intel / Altera	$54.00	$17,835.6	9.2x	9.8x	31.4x	Cash
	Field-programmable gate array (FPGA) technology.						
05/05/15	PTC / ColdLight	N/A	$105.0	13.1x	N/A	N/A	Cash
	Big data machine learning and predictive analytics						
03/02/15 05/18/15	Hewlett-Packard / Aruba Networks	$24.67	$2,758.6	3.4x	3.0x	14.0x	Cash
	WLAN access points, controllers, switches and routers, network management planning, monitoring and security hardware/software						
03/01/15 12/07/15	NXP / Freescale	$36.62	$15,931.4	3.4x	3.3x	15.0x	Cash + Stock
	Microcontrollers and processors including ARM processors, Power Architecture processors, and wireless connectivity technologies						
10/14/14 08/13/15	Qualcomm / Cambridge Silicon Radio	N/A	$2,218.4	2.7x	2.9x	19.6x	Cash
	Fabless provider of end-to-end semiconductor and software solutions for the Internet of Everything and automotive segments						
08/14/14	Samsung / SmartThings	N/A	$200.0	N/A	N/A	N/A	Cash
	Platform for smart homes and the consumer Internet of Things						
07/23/14 08/12/14	PTC / Axeda	N/A	$170.0	N/A	5.7x	N/A	Cash
	Advanced cloud-based software for managing connected products and assets and implementing innovative IoT						
06/20/14	Google (Nest Labs) / Dropcam	N/A	$555.0	11.1x	9.3x	N/A	Cash
	Wi-Fi webcams and trackers, and cloud-based storage						
01/27/14 03/04/14	Sierra Wireless / In Motion Technology	N/A	$21.0	1.4x	N/A	N/A	Cash
	In-vehicle routers integrated with mobile security system, network-management and applications platforms						
01/13/14	Google / Nest Labs	N/A	$3,200.0	10.7x	N/A	N/A	Cash
	Smart thermostats, carbon monoxide/smoke detectors						
01/30/13	PTC / ThingWorx	N/A	$112.0	N/A	11.2x	N/A	Cash
	IoT software development tools						
Average				**7.5x**	**6.1x**	**25.2x**	
Median				**4.7x**	**4.5x**	**19.6x**	

Source: Company reports, FactSet, RBC Capital Markets

Risks and barriers to adoption

IoT is a hot buzzword in the tech industry, and many companies are rushing to introduce the next smart "thing" to become the next Nest or Fitbit. In our opinion, the biggest benefit of IoT lies in the ecosystem of connected devices that provides full visibility and enables users to control their devices from anywhere in the world. Ironically, this also represents the greatest risk and a barrier to adoption because connected data are vulnerable to cyber attacks. We identified five major risks and barriers to adoption for IoT: (1) security; (2) privacy; (3) cost of technology; (4) interoperability; and (5) legal & regulatory standards.

- **Security:** Connecting devices to the network and transferring data across devices introduces a new layer of risk that was not present with traditional solutions. The connection to the endpoints represents additional points of entry for the threat actors. A security breach not only affects data on the network, but hackers may also gain control of the underlying device, which could have more damaging effects (e.g., hackers gaining control to autonomous vehicles or power plants).
- **Privacy:** Goes hand-in-hand with security concerns. Some industries, especially the financial services and healthcare sectors, have a large database of sensitive customer and patient information, including bank account information, social security numbers, and medical records. As mentioned previously, the emergence of IoT has also made data more susceptible to attacks. Customers are concerned with when and how their personal information is collected and shared. Education and forming a trust with customers should ease these concerns.
- **Technology:** To spur a widespread adoption of IoT, the cost of embedded technology should continue to drop. While the competitive advantage and cost-savings from IoT are likely to drive enterprise adoption, on the consumer side, IoT devices are added costs in many cases (e.g., buying a fitness tracker, connected cars), without offsetting cost savings. In addition to low cost, connected devices and the embedded technology must have a small form factor. A smaller footprint enables sensors to be deployed in almost every object, thereby leading to a greater network of devices, which in turn results in greater business insights.
- **Interoperability:** A critical element of IoT is to enable the free flow of data in the network across all the connected devices. McKinsey estimates that at least 40% of potential IoT benefits would be lost without interoperability. The IoT market is still fragmented, with some vendors only offering a proprietary ecosystem with limited set compatible IoT systems, which may deter adoption. While full interoperability is probably not feasible, we think the market is moving in the right direction, as many IoT technologies are becoming standardized with specific protocols. We also note that more IoT vendors offer platforms that are based on open standards and work across both proprietary and third-party devices.
- **Legal policies & regulations:** In some cases, regulations are the main hurdle in IoT adoption. IoT brings new technology and uses cases to various industries that may require new regulations and policies that did not exist previously. One major example is the driver-less car. Even after the technological and safety issues have been ironed out, policies regarding when and where these cars are allowed to operate will be a key determinant in the success of autonomous cars.

Companies mentioned

Amphenol Corporation (NYSE: APH; $60.40; Top Pick)

Cisco Systems Inc (NASDAQ: CSCO; $30.87; Outperform)

Impinj Inc. (NASDAQ: PI; $19.97; Outperform)

Intel Corporation (NASDAQ: INTC; $34.57; Sector Perform)

Sensata Technologies Holding N.V. (NYSE: ST; $38.41; Sector Perform)

Synopsys, Inc. (NASDAQ: SNPS US; $55.74; Outperform)

TE Connectivity Ltd. (NYSE: TEL; $59.99; Outperform)

Priced as of market close, August 12, 2016

Required disclosures

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