THE INTERNET OF THINGS

STATE OF TECHNOLOGY REPORT

PRESCOUTER

João Guerreiro

Sofiane Boukhalfa

ABOUT PRESCOUTER

PRESCOUTER PROVIDES CUSTOMIZED RESEARCH AND ANALYSIS

PreScouter helps clients gain competitive advantage by providing customized global research. We act as an extension to your in-house research and business data teams in order to provide you with a holistic view of trends, technologies, and markets.

Our model leverages a network of 2,000+ advanced degree researchers at tier 1 institutions across the globe to tap into information from small businesses, national labs, markets, universities, patents, startups, and entrepreneurs.

CLIENTS RELY ON US FOR:

Innovation discovery

PreScouter provides clients with a constant flow of high-value opportunities and ideas by keeping you up to date on new and emerging technologies and businesses.

Privileged information

PreScouter interviews innovators to uncover emerging trends and non-public information.

Insights, customized

PreScouter finds and makes sense of technology and market information in order to help you make informed decisions.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In this report, we explored the Internet of Things (IoT), and its impact on four industries: manufacturing, residential, retail, and healthcare. We looked at the state of the market, and interviewed a few of the interesting innovators working in these spaces to highlight the state of this nascent industry.

Here are a few of the trends and projections we saw through our research and through our first-hand experience working with clients entering the IoT space.

Smart Manufacturing:

- IoT will help manufacturers improve process automation, supply chain integration, inventory reduction, decrease downtime and increase safety.
- The market is expected to reach $2.3 trillion by 2025.
- Manufacturing is seeing the fastest growth for IoT device adoption.
- Half of all manufacturers offer smart products already.

Smart Home:

- The market is expected to reach $133 billion by 2021.
- Growth inhibitors in this market include the lack of device interoperability, device plug-and-play, and privacy and security concerns.

Smart Retail:

- Small margins and fragmentation of this market make implementation and adoption of IoT difficult, especially for smaller players.
- Retail represents 8.3 percent of total IoT market size.
- The market is expected to reach $137 billion by 2021.
- Retail has already adopted and implemented several "IoT technologies" like radio-frequency identification (RFID).
- The IoT can help create a better experience for shoppers while increasing company efficiency.
- The IoT can enable more effective targeted advertising.

Smart Healthcare:

- 64 percent of decision makers have implemented, or will implement, an IoT solution in the next 12 months.
- The market is expected to reach $1.6 trillion by 2025.
- There are a number of joint ventures between the pharmaceutical industry and technology giants.
- Security and privacy concerns are important, and highly regulated.

Cyber security:

- IoT devices are currently vulnerable from a security perspective, and overcoming this will likely increase the adoption of IoT.
    - Security concerns include lack of encryption, authentication, and authorization procedures.
- The cloud security market is expected to reach $12 billion in 2020.
- As much as $655 billion will be invested between 2015-2020 to protect mobile devices (including IoT devices).

Insights from Company Interviews:

- There is a huge opportunity for IoT in the R&D space, exceeding $100 billion in added value.
- Leveraging big data with machine learning and AI could lead to huge value creation
- The IoT will help enable a shift from a hospital-centric operational model for healthcare to a collaborative patient-centric model.
- The evolution and integration of virtual assistants, such as Siri and Cortana, with IoT devices will bring in an array of exciting new offerings.
- The primary value of the IoT does not come from the devices themselves, but from the generation of data and what can be done with it.

INTRODUCTION

WHAT IS IOT

The IoT describes the network of physical objects or devices embedded with software that allows them to interact with each other through the Internet. From printers to thermostats to espresso machines, everyday objects made with networking capabilities are dominating our world. It is expected that by 2020, tens of billions of devices will be connected to the Internet.

IoT devices often incorporate sensor-based technologies and are able to relay data to other devices connected to the Internet. With the seemingly endless array of sensors available, sensors measuring the amount of water in soil or measuring the levels of a chemotherapeutic drug in a cancer patient, the potential for the IoT is nearly limitless. The IoT is driving innovation across all industries and aspects of life. For example, nurses can monitor numerous patients' vitals or blood glucose levels on their mobile devices, or farmers can monitor the soil conditions to distribute water or pesticides appropriately.

IoT adoption in the manufacturing industry, especially, has been growing rapidly as sensors for temperature or pressure have already been used to monitor machinery. For example, when a critical temperature is reached in a sensor, some machines are able to automatically turn off to avoid damage. With the advent of the IoT, when a machine malfunctions, an alert can be sent to an employee or another machine to remedy the problem and avoid machine downtime. This ability to remotely interact with machines, and for machines to interact with each other, has changed the manufacturing industry. In the future, to maximize efficiency, manufacturers will also need to incorporate machine learning and autonomous robots into their factories.

The IoT also quickly transformed the retail industry by decreasing production costs and automating supply chain operations. However, businesses have only recently begun to tap into the revenue generating potential that comes from using advanced analytics to interpret the massive amounts of consumer data being generated and stored. This consumer data can increase revenue growth by driving improved market strategies but, more importantly, it can help businesses to better understand their customers, products, and markets. These insights can inform product development, facilitate penetration into new markets, or ultimately, lead to the development of market disrupting technologies. Aggregating the data being generated from different sources and applying the appropriate analytics is an ongoing challenge, and optimizing this will lead to the next evolution in IoT in the retail space.

The ability to interact with devices remotely and in real-time has increased the power of the IoT and is continuously changing the way we live. While today you may use a baby monitor, tomorrow you may use a wearable device that sends alerts about their blood oxygen levels or predicted wake time based on their movements or breathing patterns. With the rising number of devices connected to the Internet, it's an exciting time, but the ability to aggregate and analyze the ever-increasing amounts of data is the key to unlocking the full potential of the IoT.

MAIN ENABLING TECHNOLOGIES

The IoT is poised to radically affect all industries and sectors, due to the value it can bring users by offering additional control over their devices, and by providing novel insights into usage behavior. Although many of the components that make the IoT possible already exist, the emergence of several new technologies is accelerating the rate of adoption across various industries. These technologies include:

Novel, smart sensors

New materials and nano/micro fabrication techniques are allowing companies to build smaller, more robust, high-performance sensors. Coupling this trend with a decrease in cost (for example, the price of an accelerometer dropped from $2 to $0.40 between 2006 and 2015) is allowing many companies to include a variety of sensors in their offerings.[1]

Internet and communications protocols

Fully developed communications protocols allow manufacturers to connect devices from various providers and enjoy a full array of IoT offerings, while increasing data transfer speeds and security. Additionally, the adoption of new standards is increasing the interoperability of devices from different manufacturers.

Cloud technologies and infrastructure

Database sizes are now exceeding petabytes (1015 bytes) in size, and managing, storing, and analyzing such large files requires infrastructure and tools. With cloud providers like Amazon, Google, and Microsoft engaged in a price war, the storage of data is becoming more affordable, allowing IoT device manufacturers more opportunities to analyze and store data.

Augmented and artificial intelligence

The development of augmented and artificial intelligence allows for faster and more rigorous data analysis, discovering trends and patterns that can create value for customers.

A large scale research effort is starting to bear fruit in each of these domains, and their convergence is allowing businesses and users to enjoy an array of powerful, connected devices, which continuously collect and analyze data, creating value throughout the value chain and across industries. As development continues, IoT devices will soon touch every facet of our daily lives.

1. Inside the Internet of Things (IoT), August 21, 2015, Deloitte University Press.

QUANTITATIVE IMPACT OF IOT

As the IoT becomes ubiquitous, it will play an increasing role on the way we interact with all of our devices. The ability to make devices "smarter" and more aware of their environment allows businesses to build interfaces that benefit how consumers interact with them and their service providers. Yet, the greatest benefits might be in the industrial sector, by taking advantage of Machine-to-Machine (M2M) and Business-To-Business (B2B) seamless communication. By capturing and understanding more data than ever, the IoT is the tool that will allow businesses to reach true interoperability throughout the supply chain.

- The IoT market is projected to grow from $130 billion in 2015 to $890 billion by 2022 at a 33 percent compound annual growth rate (CAGR) over the next six years.
- By 2025, the total global worth of IoT technology could be as large as $6.2 trillion.
- The increase in the number of devices shows how prevalent IoT is likely to become in the future. There are currently over 16 billion devices and connections to the Internet. Cisco estimates this to increase by 10 billion by 2020, or a total of 3.4 devices and connections per capita. M2M connections are expected to grow at an even higher rate, reaching 12.2 billion by 2020 from the existing 4.9 billion in 2015.[2]
- Both the current 16 billion and the 26 billion devices expected to be connected by 2020 account for less than 2 percent of the 200 connectable "things" per person available today.[3]
- As more connected devices are introduced, a increase in Internet traffic is expected. The IoT will play a large role in the forecast increase from 0.8 zettabytes in 2015 (1 zettabyte = 1 trillion gigabytes) to 2.3 zettabytes of annual global Internet traffic by 2020 , according to Cisco.[2]
- The IoT accounts for only 2 percent of the world's data today, but as the number of IoT devices increase, it could represent up to 10 percent of the world's data.
- The increase in data generation will also require better analytics. McKinsey & Company estimates that only 1 percent of data from an oil rig with 30,000 sensors is actually examined.[4] To reap the full benefits of the IoT, data analysis must move from control and detection to process optimization and prediction.

2. Cisco Visual Networking Index Predicts Near-Tripling of IP Traffic by 2020, June 7, 2016, Cisco.

3. Embracing the Internet of Everything To Capture Your Share of $14.4 Trillion, 2013, Cisco White Paper.

4. Unlocking the potential of the Internet of Things, June 2015, McKinsey & Company.

KEY ADVANTAGES

The IoT creates value for both businesses and users in numerous ways. As the adoption of IoT devices continues to increase, increased development in the hardware and software will increase the value that can be generated from these technologies. Today, the IoT already offers several key advantages, we have highlighted the primary advantages below.

GENERAL:

- Businesses can increase efficiency and profits, reduce asset loss, inventory size and inventory waste for perishables, gain more satisfied customers, and decrease customer turnover by using the IoT to automate supply chain operations, ensuring product deliveries are made on time and inventory is tracked.
- Businesses can drive innovation, gain increased market share, or develop new streams of revenue for businesses by using the consumer data generated by the IoT to inform product development.
- Business can increase product sales and revenue growth by leveraging the advanced analytics of data generated by the IoT to help make informed business strategy and planning decisions.

MANUFACTURING:

- The IoT can help predict maintenance and decrease machine downtime, saving costs for manufacturing facilities.
- The IoT can provide energy-saving benefits by controlling machine/device usage automatically, based on data generated by sensor-based technologies and previous usage patterns in factories.
- Increased safety and process automation, brought by increasing control over factory machines and processes.

RESIDENTIAL:

- Create convenience for users and save them time by automating daily routines using IoT devices in the home.
- Increased customization and enhanced user experience through device interoperability.
- Utility savings by optimizing heating and cooling in the home through IoT devices' sensors and predicative machine learning.

HEALTHCARE:

- Increased the safety for patients by increasing the accuracy of disease outcome prediction and decreasing human error in diagnosis and treatment.
- The IoT allows better access to patient data for doctors and physicians, increasing communication with healthcare providers and paving the way to personalized medicine.
- Reduced costs by decreasing inventory size and waste and improved personnel and patient allocation by using the IoT for resource management.

RETAIL:

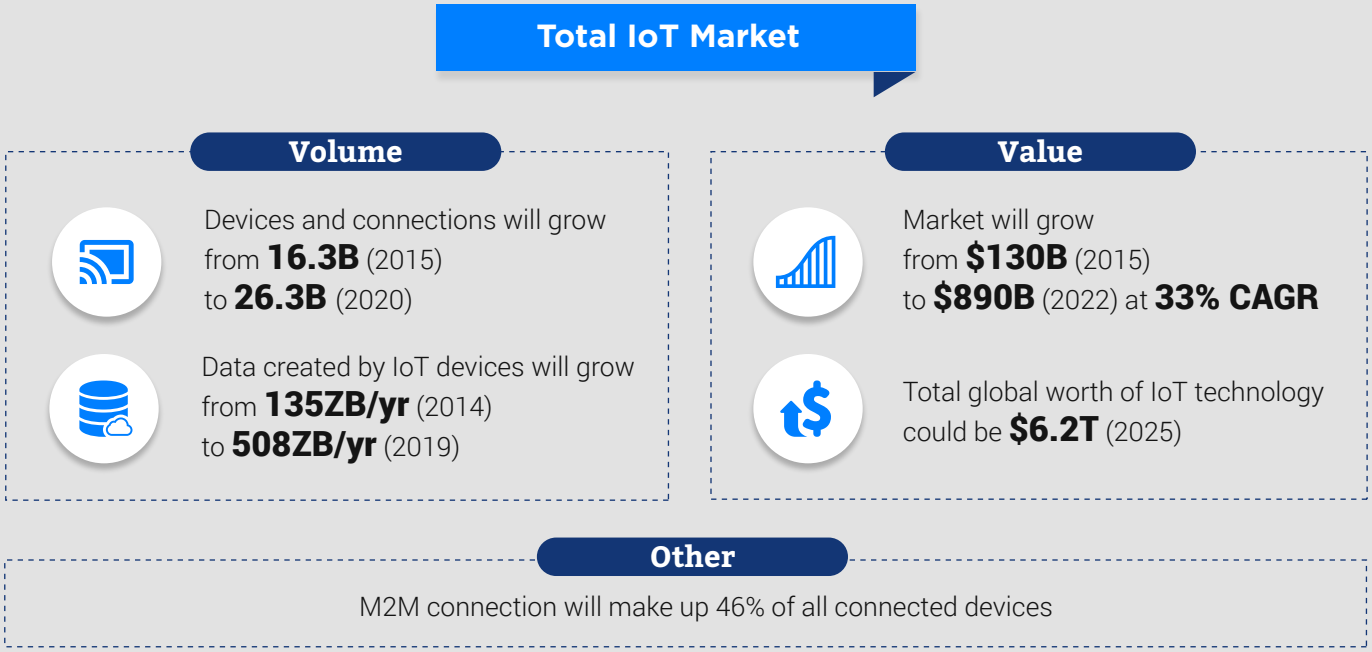
- Inventory monitoring and tracking real-time triggers to increase sales by using the IoT to help logistics and supply chain management.
- Increased customer satisfaction by using the IoT to allow customers to access additional information such as reviews or product variants.
- More effective marketing and better customer targeting using tailored campaigns, based on a customer's purchasing profile or location within a store, leading to increased sales.

FINDINGS

MARKET SIZE AND GROWTH

GLOBAL IOT MARKET:

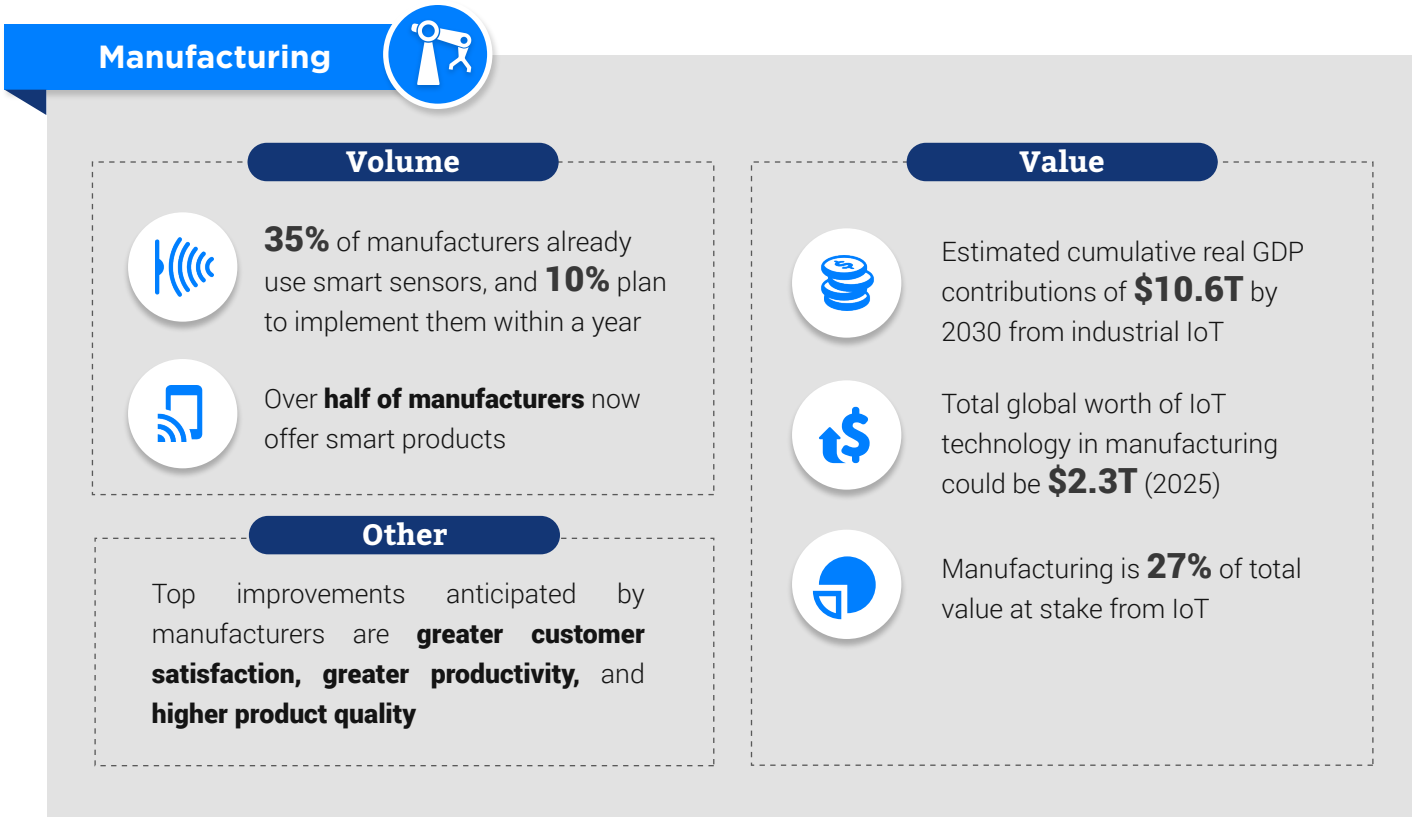
The IoT market is constantly evolving, with companies innovating and creating new IoT offerings at a rapid pace. The number of devices and connections is expected to grow from 16.3 billion in 2015 to 26.3 billion devices by 2020, generating 508 zettabytes of data per year by 2019 (135 zettabytes of data were generated in 2014)[5]. Interestingly, M2M connections will make up 46 percent of all connections worldwide. Because the devices will be generating more and more data, while the number of connections will grow at approximately 10 percent per year, the amount of data will grow at approximately 30 percent annually.[5] By 2025, the total global worth of IoT technology could be as large as $6.2 trillion.[5]



5. Internet of Things Technology Market by Hardware, Platform, Software Solutions, and Services, Application, and Geography - Forecast to 2022, September 2016, Markets and Markets.

SMART MANUFACTURING:

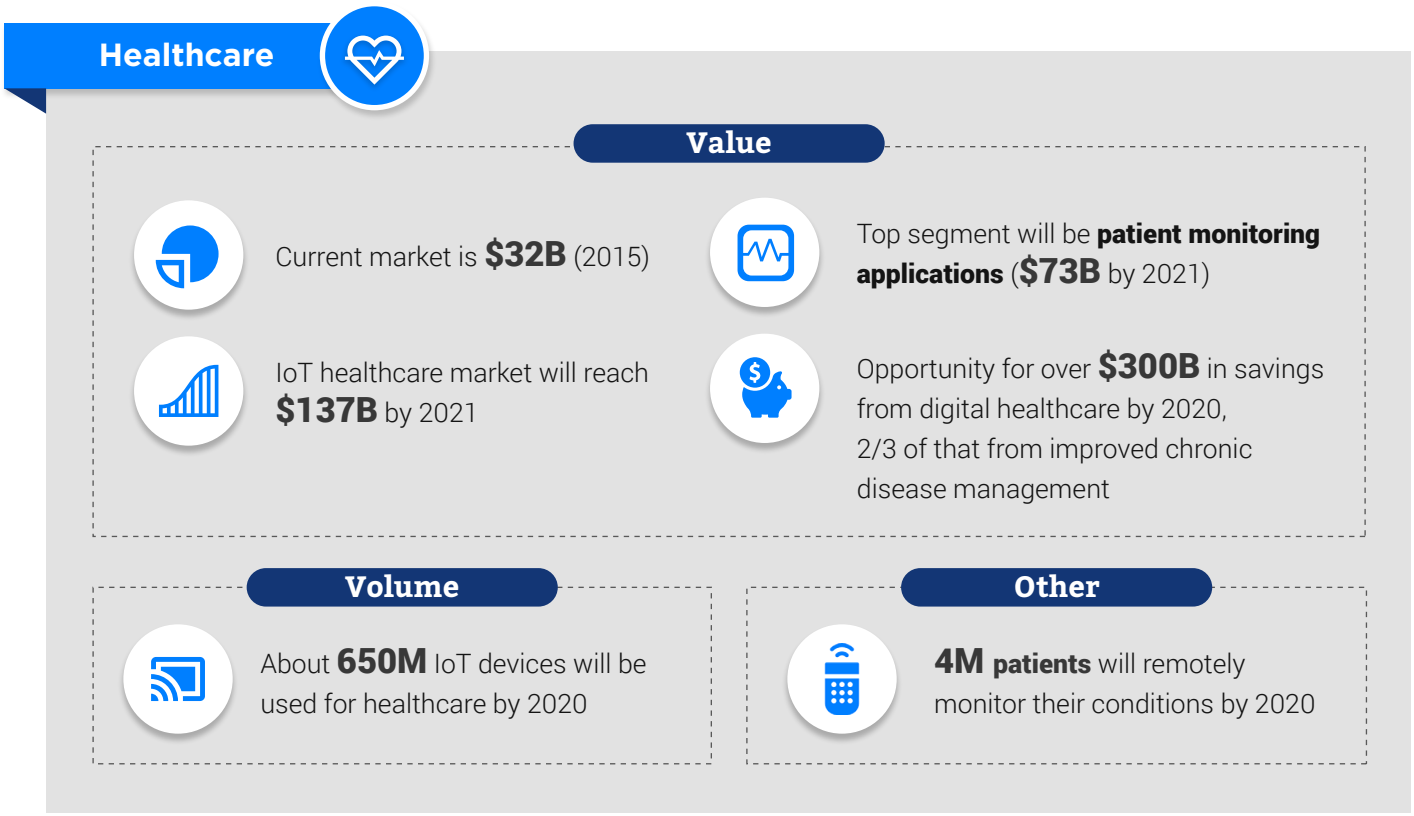
In the manufacturing industry, the IoT is radically altering the landscape, allowing companies to increase productivity and product quality, thereby increasing customer satisfaction. In fact, manufacturing currently represents 27 percent of the total IoT market. Over half of manufacturers offer smart products today, with 35 percent already using smart sensors, and 10 percent planning to implement them within a year.[6] The estimated cumulative real gross domestic product (GDP) contribution from industrial IoT will be worth $10.6 trillion by 2030, with the total global worth of IoT technology in manufacturing reaching $2.3 trillion by 2025.



6. Embracing the Internet of Everything To Capture Your Share of $14.4 Trillion, white paper published by Cisco, 2013, Cisco.

SMART HEALTHCARE:

In healthcare, the number of IoT devices is expected to reach 650 million by 2020. The value of this market will grow at a CAGR of approximately 33 percent from $32 billion in 2015 to reach $137 billion by 2021.[7] The IoT will create an opportunity for over $300 billion in savings from digital healthcare by 2020, with two thirds of that coming from improved management of chronic diseases. The top segment in healthcare IoT will be patient monitoring applications, reaching $73 billion by 2021. It is estimated that four million patients will remotely monitor their conditions by 2020.[8]

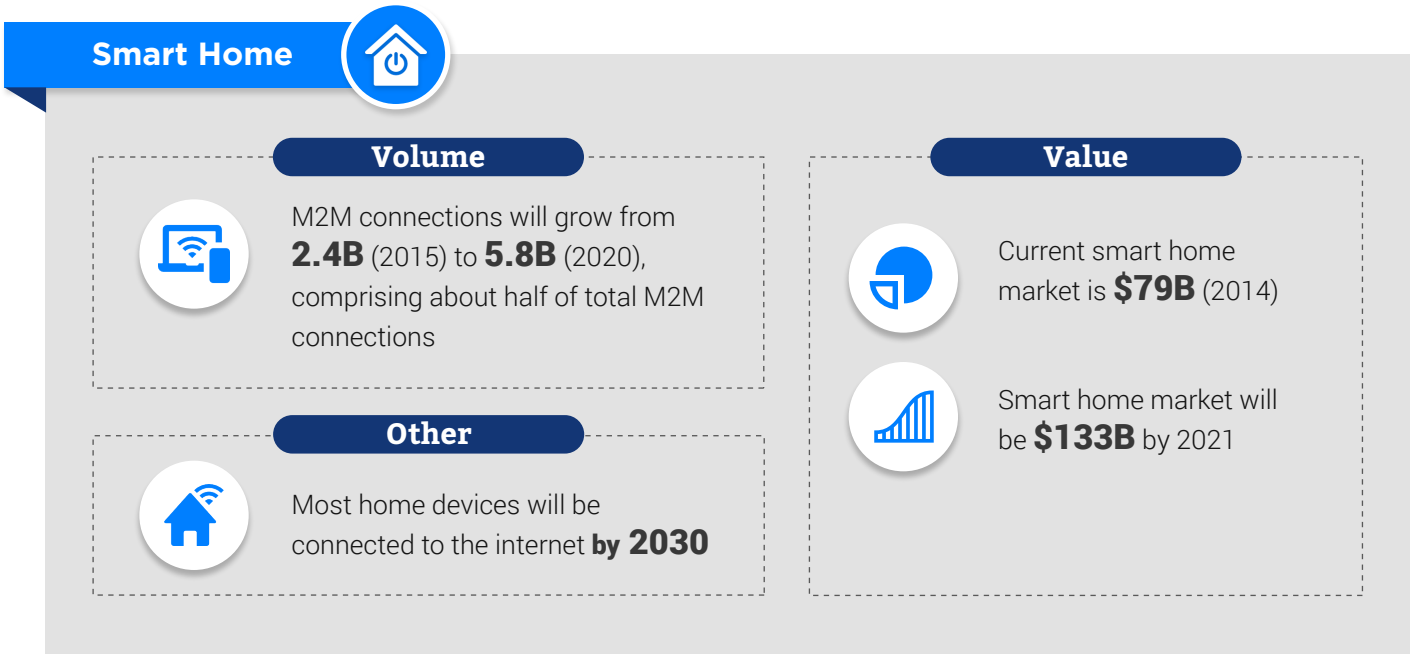


7. Goldman Sachs says a digital healthcare revolution is coming — and it could save America $300 billion, June 29, 2015, Business Insider UK.

8. IoT Market, Postscapes.

SMART HOME:

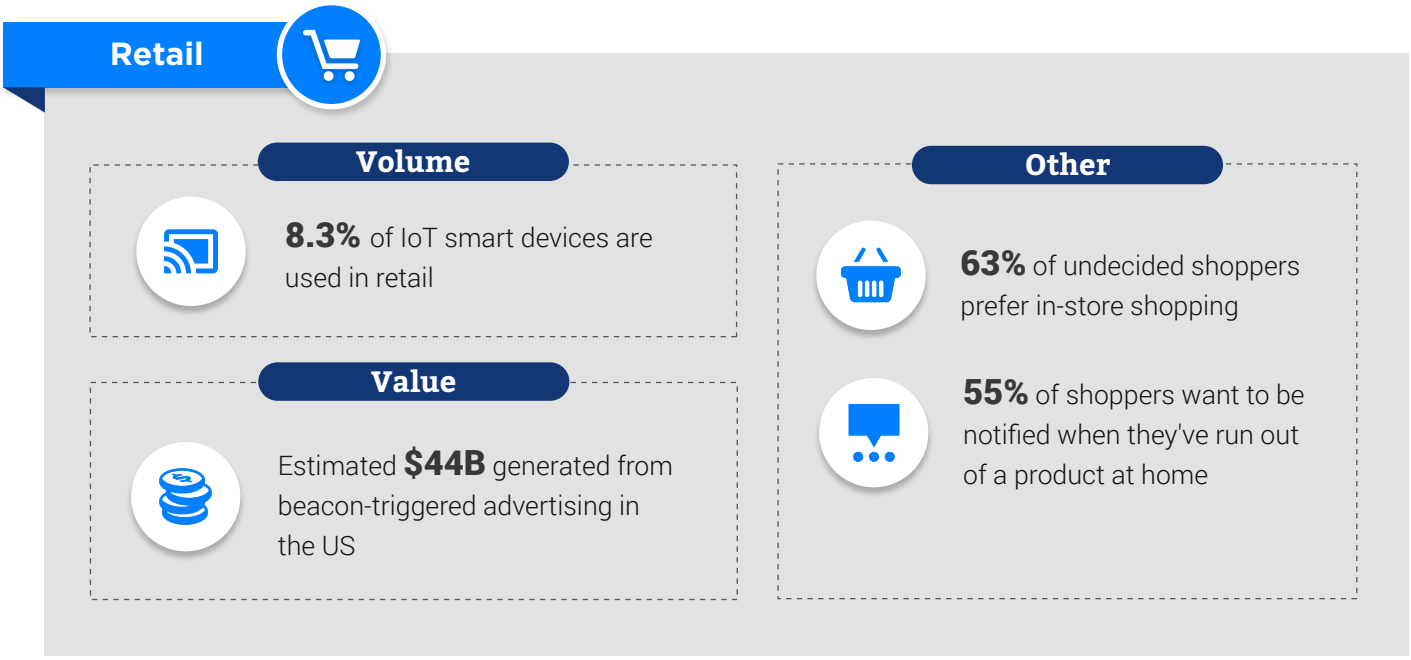
The smart home market will grow at a CAGR of approximately 8 percent from $79 billion in 2014 to reach $133 billion by 2021. By 2030, most of the devices in your home will be connected to the Internet, and it is expected that M2M connections will grow from 2.4 billion in 2015 to 5.8 billion in 2020, making up about half of total M2M connections.[9]



9. Connected Home and IoT: Market Opportunities and Forecasts 2016 – 2021, March 2016, Compass Intelligence.

SMART RETAIL:

While the retail industry is currently behind manufacturing in terms of adoption of IoT devices, using 8.3 percent of IoT devices today, the value that IoT devices can create in this space should lead to increased adoption. For example, 55 percent of shoppers want to be notified when they've run out of a product at home, the answer: IoT. It is projected that an estimated $44 billion will be generated from beacon-triggered advertising in the U.S. alone.[10]



10. IoT Projections: $44 Billion from Beacon Messaging, 220 Million Connected Cars, November 9, 2015, Media Post.

BARRIERS TO ADOPTION

While IoT adoption has been steady across different industries, moving toward full integration will require overcoming some hurdles still in place. This is true, in particular, if the IoT is to achieve the ubiquitousness many have been promising, unlocking the capabilities of the IoT to their full potential. Stakeholders have raised relevant points that will need to be addressed as the IoT grows. These range from how data is collected, saved, and transmitted to how reliable or affordable the devices are. Some of these key barriers are below:

- **Security** – The IoT promises to connect your houses, vehicles, and medical devices. All of these devices are going to be connected to the Internet, they are vulnerable to attacks by hackers. All of these sectors have had examples of breaches in the past, smart car systems, online baby monitors, or medical device companies that had user data stolen. IoT developers need to take security as a paramount priority or risk seriously damaging the field's prospects.
- **Privacy** – While our public lives have never been so exposed with the advent of social media, interest in privacy is also at an all time high. Privacy was listed as one of the main consumer concerns in adopting more IoT devices. The thought of your own devices being used to record or track you, and that information sold to or used by a third party without your knowledge is a frightening scenario. IoT-enabling companies need to build trust as they ask their customers for more of their data.
- **Data Analysis and Interoperability** – The IoT is only as useful as the information extracted from it. Using sensors to collect data and smart devices is just one part of the equation. Tools must be developed to make the most of the data. Different devices must be able to understand and communicate with one another. For the IoT to be the game changer it has the potential to be, the data must be turned into improving experiences, optimizing processes, predicting problems and trends, and seamless integration of real-time decisions made by autonomous machines and devices
- **Energy** – IoT devices and sensors require energy. One of the major challenges into making everyday objects smart and connected is the problem of how they will be powered, and for how long. While new batteries and wireless power technologies are being developed to solve the problem on the devices, the rise of the IoT industry will still demand more energy to both power and process all the information being gathered.
- **Cost** – While there has been a sharp decrease in the costs of the production of sensors and tags, paving the way for IoT, there are still sensors that are too expensive to use in certain industries or sectors. The development of software solutions capable of coping with the large amounts of data the IoT generates and providing actionable solutions while enforcing security and privacy standards is not mature. Until these solutions develop fully, smaller scale businesses or low profit sectors might find it hard to adopt IoT technology.

While these hurdles are relevant to every industry sector, some sectors are more exposed to them than others. We have taken a closer look at each of the four sectors we highlight in this report:

SMART MANUFACTURING – Manufacturing is expected to have one of the largest growth rates in IoT, powered by the potential savings it can bring to the sector. However, there are some challenges to its implementation. Small margins make many stakeholders in this sector risk averse. Installing novel systems and giving them control over a process must be supported by strong data to prove benefit in the investment and provide enough assurances that the system is reliable. The sector has been struggling the most with data integration. The increase in automation has led to more and more data being collected, but for the IoT to be a worthwhile investment, the information gained from these devices must be actionable.

SMART HOME – Smart home is perhaps where IoT can most alter our day-to-day lives. The sector is particularly vulnerable to privacy concerns due to its closeness to the consumer. Another significant issue is energy demand. Additionally, the consumer expectation for portability is entrenched, so wired connections are not desirable. Finally, a crucial challenge in the smart home is interoperability. Proprietary software and platforms can make it difficult for the devices to communicate with each other and to have a common dashboard to control your smart home. The smart home must make life easier for their users, and for that to be true, control of each device cannot require its own system, platform, or app.

SMART RETAIL – The retail sector has shown some of the greatest innovations in this field. Large retailers have experimented with IoT at different levels but, similar to manufacturing, the small margins can be a hurdle to implementation. This is particularly true for smaller scale businesses, which still make up a significant part of the sector, and account for more in developing economies. While improvements in inventory management are a clear benefit of IoT in the sector, better data analysis is required to connect purchasing trends with existing offers and advertising, or customizing the retail space to the consumers that visit it.

SMART HEALTHCARE – While the continuous demands for increased efficiency within the healthcare sector make it an ideal candidate for IoT, some important hurdles must be taken into consideration. Data security and patient privacy are paramount in this sector. Patients' health records are particularly protected and any breach can be costly for the providers. Also, with devices able to directly interact with patients, there must not be any vulnerability for an intruder to exploit. As long as developers of IoT devices for healthcare keep these concerns in mind, the main challenges should be convincing medical professionals to give IoT a chance, by focusing on the benefits for them and for their patients. For devices that interact with patients, regulatory concerns must be taken into account, as they can represent a significant increase in development costs and time to reach the market.

APPLICATIONS:

SMART MANUFACTURING / FACTORY

Smart Factory

Production flow monitoring:

Monitor production flow in real-time to eliminate wasted time and reduce in-process inventory

Inventory room:

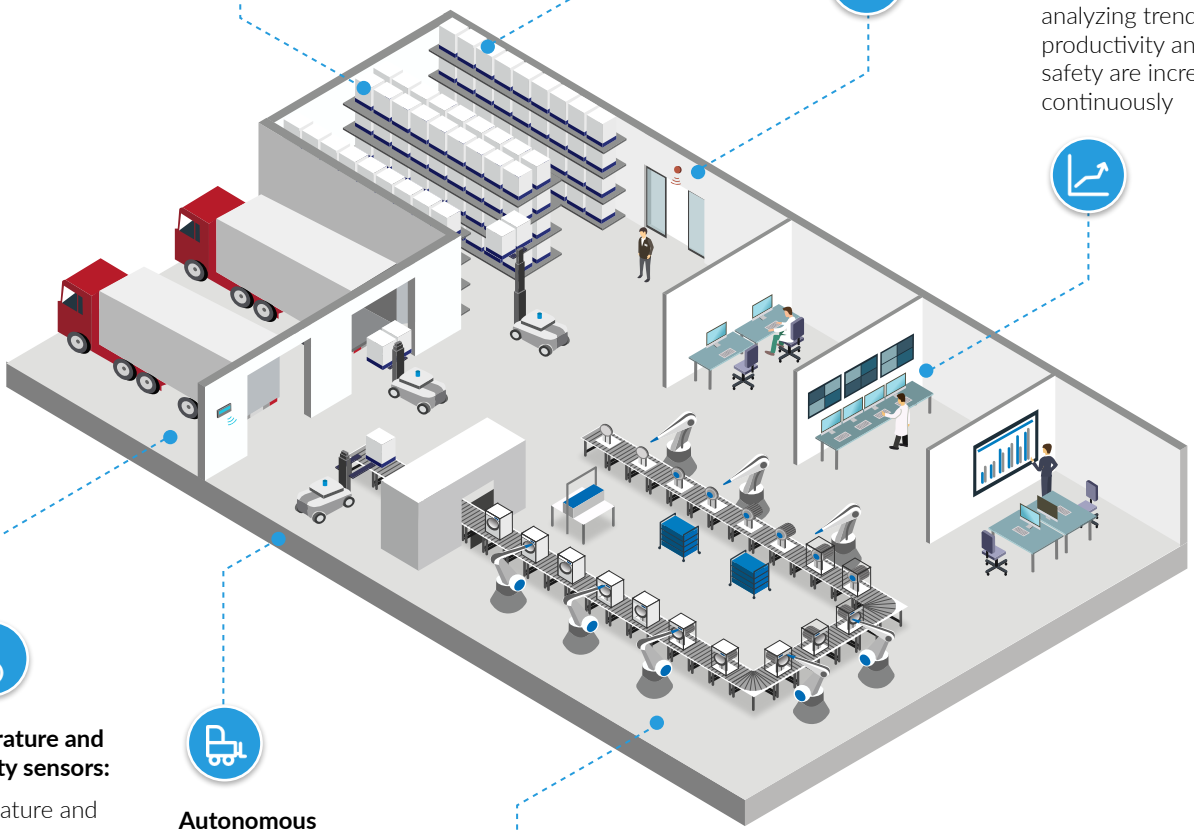
Robots automatically log, manage, and transport goods to and from the assembly line

Entrance to factory and loading areas:

Personnel and incoming/outgoing deliveries automatically logged via RFID reader or smartphone tracker

Data/server room:

By monitoring incoming data and analyzing trends, productivity and safety are increased continuously



Temperature and humidity sensors:

Temperature and humidity sensors monitor the ambient environment, automatically keeping the factory at optimal settings throughout the day

Autonomous material handling vehicles:

Production line triggers autonomous material handling vehicles

Lines of manufacturing robots:

Sensors placed on machinery and automated assembly line predicts downtime, requests its own maintenance, and optimizes assembly process for increased efficiency

MARKET INFO

IoT advances have numerous applications in the manufacturing sector, and will enable companies to increase efficiency, reduce downtime, increase safety for their workers, and save on maintenance costs. According to a 2015 Markets and Markets Report, "the IoT in manufacturing market is estimated to grow from USD 4.11 billion in 2015 to USD 13.49 billion by 2020, at a CAGR of 26.9 percent."[11] Although this is a global phenomenon, North America is expected to dominate the market throughout this forecast timeframe.

Major drivers for this explosive growth include decreased hardware and connectivity costs, increased requirements for efficiencies in manufacturing plants, and the increased need for predictive maintenance, security, and analytics. These predictive technologies are becoming a reality thanks to the emergence of low cost, high reliability sensors.

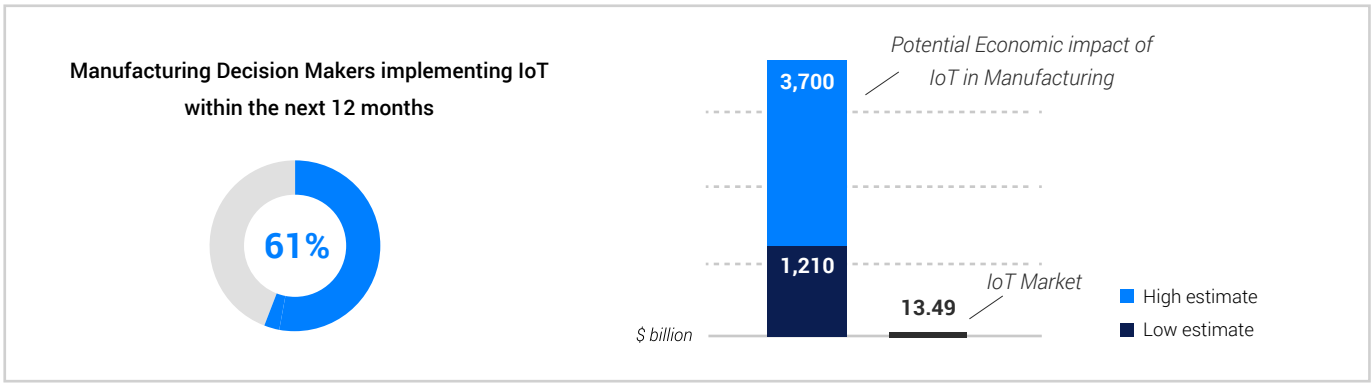
Due to the need for these sensors, there is competition in this market, with established players like Intel and Cisco competing against start-ups with novel offerings. The ability to distinguish oneself will be essential to capturing market share, and will rely on technical prowess, B2B relationships and sales, and a thorough understanding of the different industries' requirements for IoT (e.g., predictive maintenance for high volume hardware manufacturing compared to the focus on safety and hygiene in the food and beverage industry).

WHAT IS A SMART FACTORY?

WHAT DOES IT ENABLE?

Traditionally, a factory is an industrial site where raw materials are converted to manufactured or processed goods. Factories commonly involve multiple buildings, several workers manufacturing goods and many machines processing one product into another; refer to Figures 1 and 2.

Consider the efficiency, in terms of savings of time, effort, and money, of a factory that operates within a dense communication network, where information is



Left, Industry decision makers insight into IoT [68]. Right, Estimated potential impact of IoT applications by 2025 (Low estimate - dark blue, High Estimate - light blue)[69] and IoT market size by 2020.

11. Internet of Things (IoT) in Manufacturing Market worth 13.49 Billion USD by 2020, December 2015, Markets and Markets.

communicated across other systems and parts of the production system, autonomously. Such an efficient, self-aware factory is considered a "smart" factory. The smart factory has the potential to autonomously manage aspects of its own production systems. For example, logistics can be improved through automatic replenishment of parts from suppliers when inventory is running low. The system may also manage timing based on communications from its parts. Finally, by closely monitoring the performance of various manufacturing units, one can increase efficiency, predict potential failures, and manage these in order to decrease downtime, which can cause hundreds of thousands to millions of dollars in lost earnings.

Apparent differences between factories include: output, input, staff, and processes. Figure 2 illustrates a smart factory that integrates communications among individual components of the production system. The defining feature of a smart factory is integration of, and communication between, individual components, allowing for smarter, more efficient cooperation throughout the factory. "The future of smart manufacturing is today," says Helmuth Ludwig, CEO, Siemens Industry Sector, North America, as quoted in the IndustryWeek, "Previously, the industrial value chain, including product design, production planning, production engineering, production execution and services were implemented separately," he says. "Today, new technologies are bringing these worlds together in exciting ways." [5]

An example of a smart factory technology is Ayla Insights, from Ayla Networks. Ayla Insights is a fully integrated business intelligence and analytics platform that provides manufacturers with real-world insights into how their connected products are being used.[14] Ayla Networks recently announced a $39 million investment furthering its global IoT platform for manufacturers.[15] As reported by Business Wire," Ayla's Series C financing round comes from a broad group of global investors led by Ants Capital, a boutique investment bank and asset management company with headquarters in China and investment interests in

FIGURE 1: General Motors facility [12]

FIGURE 2: Siemens' Electronic Works facility in Amberg, Germany [13]

12. U.S. Factory Output Rises for Second Straight Month, Jan 16, 2013, CBS Money Watch.
13. The Dawn of the Smart Factory, Feb 14, 2013, IndustryWeek.
14. Ayla Networks web site.
15. IoT Platform Provider Ayla Networks Announces $39 Million in Series C Financing, July 27, 2016, Ayla Networks Press Release.

China, North America and Europe."[15] Yin Min, managing partner of Ants Capital said this about their investment, "Our strategy at Ants Capital is to focus on the leading platforms in particular market segments and select winners. The IoT will be the next area where major winners will emerge, and we invested in Ayla because it has unmatched traction inside China and globally with leading manufacturers making IoT products. Ayla's strategy and IoT platform is a clear fit with the direction of manufacturers worldwide."[15]

A smart factory is distinguished by the integration of communicating components and enables the management of variables and complex supply chain mazes, common to many production processes, which far exceed the capabilities of a traditional factory. Smart factories like Siemens' state-of-the-art Electronic Works facility in Amberg, Germany, integrate manufacturing, production, and automation systems to process 1.6 billion components from 250 suppliers with 99 percent reliability.

In addition to enabling a deep view of industrial processes and subsequent improvements in real-time, these extant applications of smart factory technologies suggest the boundless extent of potential applications. Some of these potential applications are:

- **Advances and process automation** – The dense mesh of communication and cooperation of autonomous entities in a smart factory can lead to the automation of many procedures in industrial processes. Industrial robots equipped with technology to communicate with other robots and machines can quickly calculate time.
- **Supply chain integration** – Managing the logistics of a supply chain can be a challenge. The dense mesh of communication within the smart factory may be enabled to branch out of the factory. In addition to the benefits of communicating the status of parts within the factory, a smart factory may enable reports to be sent to suppliers.
- **Increased efficiency and decreased downtime** – The production system within a smart factory can become, in a sense, "self-aware," to allow a system to optimize its internal timing and order needed parts during operations can increase overall efficiency.
- **Customer service** – Product tracking can be useful in quality assurance and customer satisfaction.
- **Increased safety** – Because of increased automation, fewer personnel need be directly involved in the production system, thereby increasing employee safety.
- **Reduced inventory** – Smart factory operations can resemble on-demand production, so there is likely to be a reduction of inventory, in terms of raw material and completed products. Reduced inventory leads to savings in required storage space, aging products, and security issues.

KEY TECHNOLOGIES

In this next section, we would like to illustrate the state of this industry by highlighting developments from some of the biggest firms vying for market share in this space. The focus is on technology offerings, market share, and strategy to highlight where the industry is going.

ROCKWELL AUTOMATION

Company Description

Rockwell Automation is the world's largest company focused on industrial automation. Its headquarters are located in Milwaukee, Wisconsin and has over 22,000 employees worldwide. It ranks fourth among the Top 50 Global Automation Vendors and generated $6.3 billion in global sales in 2015. Rockwell Automation refers to the opportunities offered by the IoT as "the Connected Enterprise" which reflects their drive to create an IoT portfolio that enables highly efficient integration and collaboration.[16]

Approach to IoT

Rockwell Automation's Connected Enterprise portfolio is focused on integrating information technologies (IT) with operational technologies (OT) to optimize efficiency for business operations, plants, and supply chains. In order to efficiently integrate IO and OT, Rockwell Automation collaborated with Cisco to design software and hardware products such as the Allen-Bradley® Stratix 5900™ Services Router that will provide a more secure and flexible convergence of IT and OT. The company's Connected Enterprise execution model promotes five key steps for their customers to safely and efficiently incorporate IoT solutions:[17]

- Comprehensive baseline infrastructure and network assessment
- Secure and upgrade potential network and operation weaknesses, identified from Step 1
- Define and organize working data capital
- Monitor and analyze real-time data-based analytics
- Optimize and collaborate by sharing data across devices, people, sites and processes

In the first step of Rockwell Automation's Connected Enterprise execution model, the company seeks to help clients identify potential weaknesses in their existing information infrastructure, security, and network communications. After establishing baseline assessments of possible vulnerabilities, the next step in the approach is to upgrade the client's systems and processes using modern information-enabled control technologies. In collaboration with Cisco, the Connected Enterprise incorporates a common network infrastructure using protocols such as Ethernet/IP to provide secure, real-time analytics and control of system processes. The third step in the Connected Enterprise IoT execution model is to extract and share contextualized data across siloed facilities to provide real-time, actionable information. The fourth step involves the comparative analysis of real-time

16. Connected Enterprise Execution Model, 2016, Rockwell Automation.

17. Manufacturing Growth Continues Despite Uncertain Economy, According to ASQ Outlook Survey, December 17, 2013, American Society for Quality.

information with historical performance data to improve plant operations and optimize the precision of customer support. The fifth, and final step, employs new IoT technologies to provide easier, more efficient, and cloud-based scalable solutions to streamline the supply line and best practices across different sites. The availability of smart mobile devices grants workers real-time information critical for tasks such as diagnostics, downtime events, and equipment protocols.

Rockwell Automation's Connected Enterprise IoT solution offers great potential to clients, 82 percent of corporations incorporating smart manufacturing reported improved efficacy, 49 percent reported reduced product defects, and 45 percent reported high customer satisfaction. [17]

Specification for Hardware and Software

As a world leader in industrial automation, Rockwell Automation has a number of IoT solutions in the form of hardware and software products. By forming strategic alliances with corporations such as Cisco and Microsoft, Rockwell Automation has been able to deeply integrate its Connected Enterprise solutions for industrial automation on a global scale. The products in their extensive IoT portfolio have garnered significant recent media attention, including the Allen-Bradley® Stratix 5900™ Services Router, vMonitor™ SCADA System, and the Industrial Data Center.

The Allen-Bradley Stratix 5900 Services Router is a robust router designed specifically for industrial automation.[18] In collaboration with Cisco, Rockwell Automation designed this router to fully integrate Cisco IOS to provide secure, real-time control communications and enable easier machine integration with a single device. The router's VPN and firewall features are currently being used by companies to manage their industrial switch lines and connect remote outstations. The combination of a VPN and firewall within a single device ensures a secure and robust network.

In 2013, Rockwell Automation acquired vMonitor, which is a global leader in providing IoT solutions in the oil and gas industry. vMonitor is focused on creating the "virtual oilfield" by providing integrated software and hardware solutions for oil and gas companies, which can significantly lower operation costs compared to conventional automation solutions.[19] Hardware products include the wireless, battery operated units, called the vmBus 1, that can transmit data up to 36 km and the vmBus P, that can capture and store real-time data. The vMonitor Web-based TotalAccess eSCADA software can then be set up to automatically monitor and analyze real-time data transmitted by vmBus units to function as a secure and efficient integrated system.

Rockwell Automation's Industrial Data Center is a predesigned IoT solution that includes hardware and software that is pre-configured specifically for production and manufacturing facilities.[20] These

18. The Allen-Bradley® Stratix 5900™ Services Router, 2013, Rockwell Automation.
19. Connecting the Digital Oilfield, 2003, Vmonitor.
20. The Industrial Data Center, March 2016, Rockwell Automations.

packaged products include servers, switches, cables, storage units, Virtual System Licenses, and customer support. Furthermore, Rockwell Automation professionals travel to clients' sites to commission the system. By using the pre-configured Industrial Data Center, clients can reduce server footprint, increase system longevity, and improve infrastructure reliability compared to relying on multiple operating systems and third party applications.

Company Case Studies

Rockwell Automations Helps Hospital Save Energy with Integrated IoT Architecture

York Teaching Hospital NHS Foundation Trust is an organization that provides comprehensive acute hospital and specialist healthcare services for over 800,000 people over a 3,400 square mile territory in the UK. [21] The Vital Energi Group was contracted to devise a low-carbon energy solution. They realized that existing power meters and control system infrastructure were obsolete and decided to collaborate with Rockwell Automation. The Vital Energi Group was able to significantly reduce energy costs and carbon emissions by incorporating Allen-Bradley CompactLogix programmable automation controllers, MBus units, and Stratix 5700™ managed Ethernet switches. This integrated infrastructure gathers and analyzes real-time energy and carbon data and provides a great example of how Rockwell Automation's IoT solutions can greatly improve both efficiency and sustainability.

Rockwell Automation Improves Cyber Security for an Oil Giant

Rockwell Automation's IoT portfolio also includes cyber security solutions such as those provided for a major petroleum producer in California.[22] This petroleum producer originally relied on expensive, manual collection methods resulting in significant vulnerabilities to cyber attacks. Rockwell Automation's IoT solution involves custom programming of an Allen-Bradley SoftLogix 5800 controller to direct a new diagnostic reliability (DR) system, which is capable of tagging and tracking every device on the company's oil-field operations control network. Using the FactoryTalk® VantagePoint® software from Rockwell Automation, this data can provide a master inventory and real-time scans of security vulnerabilities. As a result, this California-based unit is now in full compliance with companywide cyber security policies based on the ISA99 standard for industrial control systems.

Relative strength in the Marketplace

Rockwell Automation is the world's largest industrial automation firm and has customers in over 80 countries. By forming strategic alliances with major corporations such as Cisco Systems and Microsoft, this company has become a global leader in IoT hardware and software solutions for production and manufacturing industries. Although Rockwell Automation has long been known for its factory

21. Hospital Saves Energy with Integrated Architecture, 2016, Rockwell Automation.

22. Oil Giant Improves Cybersecurity, Lowers Manpower Costs, 2016, Rockwell Automation.

controls, its Connected Enterprise is already making key inroads in the future of the IoT. Rockwell Automation believes that manufacturing will be the single largest share of the IoT economic output expected by 2020 and has supplied over 50 networking and switching technologies to industrial producers. Richard Eastman, an analyst at Baird Equity Research, states that "In most respects, the Industrial IoT is synonymous with Rockwell's 'Connected Enterprise', which increasingly links or networks real-time operating data into the corporate information technology system." [23]

Future Strength and Opportunities

Rockwell Automation's vision of the Connected Enterprise is driven by three focus areas in IoT: [24]

1. Integrating information technology (IT) with operations technology (OT)
2. A high performance architecture
3. An open, partner-fortified architecture

Rockwell Automation is also focused on creating high performance architecture by using Logix-based systems such as their Industrial Data Center to enable smarter, more productive, and secure architecture. Rockwell Automation has the only IoT architecture in the market that includes a complete set of real-time control tools that incorporate real-time information for optimization and is built upon one network using an unmodified Ethernet. To address the third focus of an open, partner-fortified architecture, Rockwell Automation has formed strategic alliances with other IoT leaders such as Cisco, Microsoft, AT&T, Panduit, and Fanuc to develop self-adaptive and self-optimizing automation systems.

SCHNEIDER ELECTRIC

Company Description

Schneider Electric is an international industrial technology corporation that specializes in energy management and automation. Schneider Electric was founded in 1836 with roots in the steel industry and has since shifted its focus to become a world leader in energy sustainability and the IoT. As of 2016, it has over 160,000 employees in over 100 countries, with its headquarters in Rueil-Malmaison, France. This company has approximately 20,000 patents and generated €26.64 billion in revenue in 2015.[25] It prides itself on the slogan, "Life is On," to express its focus on developing products to address the megatrends of global industrialization, urbanization, and digitization.

24. The Connected Enterprise: From Vision to Implementation, 2016, Rockwell Automation.
25. 2015 Financial and Sustainable Development Annual Report, 2015, Schneider Electric.

Approach to IoT

In September 2015, Schneider Electric announced its "Life is On" strategy focused on driving innovative IoT solutions at every level "from the shop floor to the top door."[26] The company's IoT solutions and consumer values are summarized in four vertical pillars:[27]

1. Maximizing energy efficiency and sustainability
2. Optimizing asset management
3. Smart, profitable operations
4. Mobile insights and proactive risk mitigation

Schneider Electric seeks to assist in maximizing energy efficiency and sustainability through innovative technologies such as EcoStruxure™, which provides an open, connected energy-management architecture and software suite. EcoStruxure could enable consumers and smart cities to reduce energy use and carbon emissions.[27] Using predictive analytics in fields such as oil and gas, Schnieder Electric is able to assist in compensating and preparing for failures before they occur, reducing downtime and cost. In smart operations, they are supplying resources such as resource management systems and smart grids to provide improved connectivity, make energy expenditures more efficient, and reduce CO_2 emissions. By employing augmented reality (AR), Schneider Electric is enabling mobile operators to overlay updated information over instrumentation to improve efficiency and assess potential risks in real time.

Specification for Hardware and Software

Schneider Electric has an enormous technology portfolio focused on providing IoT solutions to a wide range of areas including industry, buildings, smart grids, data centers, smart cities, and private homes. Key technologies that are spearheading their operations and attracting the most media attention include the Wonderware™ System Platform, WeatherSentry, EcoStruxure, and Schneider Electric Weather (SE Weather).

Wonderware is a software operating system designed for industrial applications. This technology was designed by Invensys, which was acquired by Schneider Electric in January 2014. Wonderware acts as an Industry Operating System by providing services, enabling clients to build a common "Plant Model" infrastructure, which integrates and connects physical instrumentation, industrial systems, teams, data, and security.[27] This system reduces development time, improves workflow efficiency, and minimizes equipment downtime. By implementing the handheld, portable device IntelaTrac, Wonderware is also able to provide updated information and standardized operating procedures to mobile workers. Wonderware is already being implemented in a wide range of industries including Mining, Water, Facilities Management, Food and Beverage, Automotive Assembly, Oil and Gas, and Energy.

26. Delivering value fueled by the Internet of Things, 2015, Schneider Electric.
27. Wonderware System Platform, 2014, Schneider Electric.

StruxureWare™ is an integrated platform of software applications and suites used for real-time tracking of energy use.[28] It's an advanced data center infrastructure management (DCIM) suite that analyzes energy expenditures and carbon emissions. This integrated platform can optimize efficiency and sustainability through applications such as automated adjustments of a facility's cooling and real-time visualization of carbon emissions. By integrating Microsoft Windows cloud infrastructure platform Azure in 2013, Schneider Electric announced that it would be able to further improve StruxureWare's security, cost, and efficiency. [29]

MxVision **WeatherSentry** GIS Web Services are cloud-based weather information services supplied by Schneider Electric that provides highly accurate and comprehensive meteorological information to weather-sensitive businesses.[30] WeatherSentry has been the number one ranked forecasting service for nine consecutive years. These integrated services offer real-time global weather data that can be used to correlate outage patterns with weather phenomena such as lightning strikes. Analytical weather prediction tools can also be used by industries such as agriculture and sports to improve communications and coordinated weather responses to reduce time and cost in their operations. These web-based services can be integrated with numerous web-linked hardware products provided by Schneider Electric, such as automatic weather stations and the Wiser Air™ Wi-Fi Smart Thermostat.

Company Case Studies

Schneider Electric Brings IoT to Agriculture with Network of 4,000 Weather Stations

On Dec. 4, 2015, Schneider Electric announced that it was using its cloud-based WeatherSentry platform to connect a network of over 4,000 rural Weather Stations.[31] By employing specialized WeatherSentry sensors to capture real-time weather and soil-conditions, Schneider Electric helped assess and predict high-risk weather variables to improve the efficiency and safety in agricultural operations. WeatherSentry demonstrated a 40-63 percent greater accuracy than other weather sources, now over 100,000 agricultural industry consumers are employing Schneider Electric's weather IoT services worldwide. This case provides an excellent example of how Schneider Electric's WeatherSentry platform can help mitigate climate changes and improve efficiency for the agricultural industry by employing IoT-enabled hardware and software solutions.

28. StruxureWare for Data Centers, July 2015, Schneider Electric,.

29. Schneider Electric Selects Microsoft Windows Azure as Preferred Cloud Platform for StruxureWare™, October 16, 2013, Cloud Strategy Magazine.

30. WeatherSentry GIS Web Services, September 2015, Schneider Electric.

31. Schneider Electric Brings IoT to Agriculture with Network of 4,000 Weather Stations, December 4, 2015, PR News Wire.

Schneider Electric Helps Green Mountain Data Center Reduce Carbon Emissions to Zero

The Green Mountain data center is a facility buried deep within a mountain in Norway, and has earned a reputation as one of the greenest data centers in the world.[32] Schneider Electric helped design the cooling system for the facility that uses gravity to divert seawater from a nearby fjord to cool its servers. Schneider Electric also installed DCIM software and hardware components and approximately 12,000 measuring points to help predict outages, improve response times, assess risks of system failures, and further reduce energy waste. This case demonstrates the potential of Schneider Electric's IoT solutions to improve sustainability as well as efficiency for industries.

Relative strength in the Marketplace

Schneider Electric (SE) has become a leading provider of IoT solutions through its widespread integration of software and hardware. Schneider Electric seeks to apply these technologies to the four target markets, building, IT, industry, and infrastructure, which represent 70 percent of the world's energy consumption. This company's expertise has already established a deep, world-wide presence with Schneider Electric technology being implemented in over 1 million buildings (approximately 40 percent of all hospitals), twenty of the top oil and gas corporations, nine of the largest mining companies, eleven top Food and Beverage brands, ten top global electric utilities and three of the four leading cloud providers. [33]

Since launching its "Life is On" platform to address increasing global energy and sustainability needs, Schneider Electric has continued developing leading software and hardware solutions. Because of this focus on development, Schneider Electric will likely continue being a world leader in IoT solutions for industries, buildings, smart grids, data centers, smart cities, and private residences.

Future Strength and Opportunities

Schneider Electric's IoT development is focused on five areas that the company predicts will be the future of IoT applications.[34] Schneider Electric refers to the first area as "the next wave of digital transformation" which is supported by a survey indicating that two thirds of organizations intend to incorporate IoT solutions via mobile applications in 2016.[35] Accordingly, Schneider is planning to further integrate mobile systems such as IntelaTrac with existing infrastructure to provide a robust network of connected devices. The second area of focus is "insightful data" in which the company seeks to augment customer experience with hardware and software that can provide enhanced analysis and

32. Green Mountain Creates Data Center Harmony with Nature, October 1, 2015, Schneider Electric.
33. An indisputable right to energy, 2016, Schneider Electric.
34. IoT 2020 Business Report, April 2016, Schneider Electric.
35. Tridium Resource Library, 2016.

contextualization of real-time data.[35] The third area that the company predicts will be a key IoT focus is "site-to-cloud confidence" due to the increasing risk of cyber security threats. [35] With this in mind, Schneider Electric seeks to upgrade client legacy systems with modern hybrid computing solutions that will provide customizable cloud-based alerts and greater security. The fourth prediction is that IoT solutions will allow for "innovations that leapfrog infrastructure." [35] Accordingly, the company is driven by disruptive innovation to create products that will allow clients to shift from existing business models and legacy infrastructure into new IoT-based models and services such as Wonderware. The fifth field of focus is making "a better planet." [35] By leveraging IoT solutions such as StruxureWare™ for improved process efficiency and reduced carbon emissions, Schneider Electric believes that the IoT will pave the way for the 195 countries that pledged their sustainability commitments to the COP21 agreement.

HONEYWELL AND TRIDIUM

Company Description

Honeywell International, Inc. is an American multinational conglomerate that produces a variety of commercial and consumer products, engineering services, and aerospace systems for a wide variety of customers, from private consumers to major corporations, and governments. Honeywell's acquisitions have consisted largely of businesses aligned with the company's existing technologies. Tridium was founded in 1995 and acquired in 2005 by Honeywell's Automation and Control Solutions (ACS) business segment. Tridium provides software that can be used to link diverse systems and devices so that they can be managed and monitored through a web browser or handheld device. Tridium's products are used for tasks such as facilities management, metering and managing energy consumption, home automation, and industrial control. The company also offers services such as consulting, maintenance, support, and training.

Approach to IoT

Tridium is the developer of the Niagara Framework, a universal software infrastructure that allows building controls integrators and mechanical contractors to build customized, web-enabled applications for accessing, automating and controlling smart devices real-time via a local network or over the Internet. The Java Application Control Engine (JACE) controller is the hardware that unleashes the power of Niagara Framework. Tridium has been collaborating with Oracle, QNX Software Systems, and other technology leaders to pioneer the IoT.

With a balanced combination of software (Niagara and Niagara AX) and hardware (JACE® Controller), Tridium makes it easier to connect, control, normalize, and analyze with several advantages:

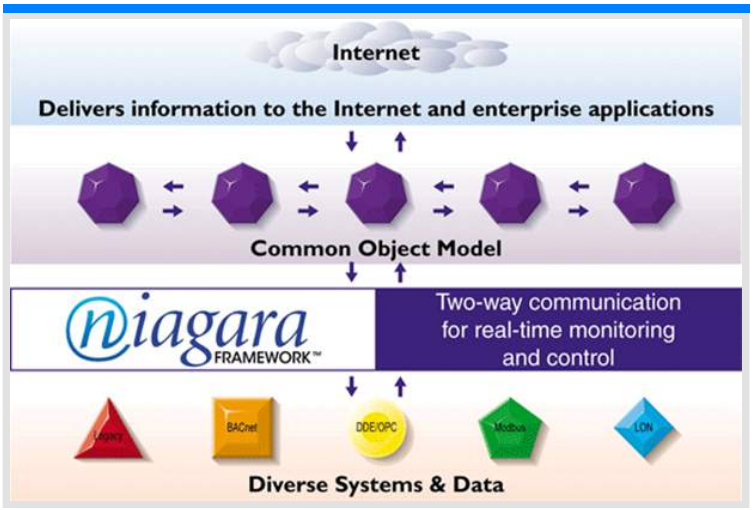
- **Ease of use and diversified functions** – Niagara AX is an open, Java-based framework that can connect almost any embedded device or system — regardless of manufacturer or communication protocol. It includes a comprehensive graphical toolset that lets the customers to build rich applications in a drag-and-drop environment and easily manage the assets using a standard web browser.
- **Embedded platforms and efficient build-ups** – The Niagara AX Framework is packed with features and functions that are easy to build on, rather than starting from scratch. Multiple embedded platforms allow for integrated control, supervision, data logging, scheduling, and alarming. Internet communications and web services support is infused throughout Niagara AX for fast application development and deployment and the creation of a robust user experience.
- **Broad range of deployment** – The Niagara AX Framework is proven, adopted in multiple markets and industries, and deployed in more than 70 countries.
- **Single Tool:** Everything necessary to get started is in a single integrated toolset for rapid and easy implementation that reduces development time.
- **Scalability and reliability of JACE controllers** – By connecting common network protocols such as LonWorks®, BACnet®, Modbus®, OPC, oBIX, and many proprietary networks, the unified system allows the scalability and reliability with unique distributed architecture.
- **Compact platform**– JACE controllers combine integrated control, supervision, data logging, alarming, scheduling, and network management functions, integrated I/O with Internet connectivity and web-serving capabilities — all in a compact platform. A JACE controller makes it possible to control and manage external devices over the Internet and present real-time information to users in web-based graphical views.

Tridium has demonstrated outstanding capability with the Niagara Framework, which allows an enterprise to provide better energy management, enhanced security, operational excellence, lower costs, and end-to-end efficiency across multiple industries applications including building automation, data centers, industrial, smart cities, and government.

Technical Specifications

Applying the Niagara Framework to energy demand response, for example, Tridium's Niagara Framework provides the physical link between external and internal systems and data. Typically, the infrastructure for a DR program requires integrating external environmental factors (e.g., pricing signals, weather data, curtailment requests, etc.) with equipment and devices in a facility that is consuming energy. Internet standards are required to connect to external data sources, while building automation and metering integration provide connectivity with energy consuming equipment within a facility.

Using Internet standards, Niagara seamlessly communicates via XML, SNMP, HTTP, oBIX, and other standard protocols, allowing external environmental data to be seamlessly incorporated into the solution. In addition to including external environmental data such as weather and pricing, the Niagara Framework integrates temperature controls, lighting panels, metering technologies, and other systems that consume energy in a facility. Common protocols such as Modbus, LonWorks, BACnet, and SNMP can all be integrated into the program. By adding connectivity to proprietary systems, demand response opportunities are significantly expanded. Once the pricing signal and curtailment request and the field devices have been linked, logic can then automate the program. The links between objects determine the DR levels and sequences and provide for an automated DR program. For example, if the aggregate kilowatts were between 5000 and 8000 between the hours of 11:00 and 4:00, and the pricing of kilowatts per hour exceeds $.50, then the system will adjust lighting in zone X, offset temperature in zone Y, and turn on the 75-kilowatt microturbine.

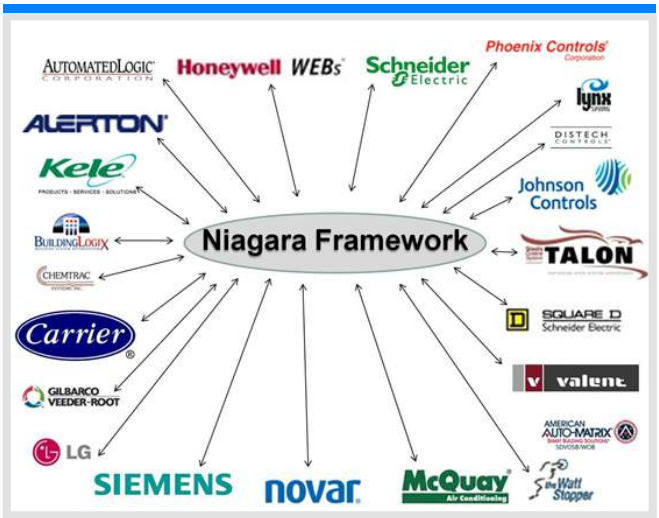


Although the DR sequences need to be automated, there will always be times where human intervention is necessary. Whether for overrides, more intensive curtailment initiatives, or real-time alarming, users need to be able to access the system from any standard web browser. The Niagara Framework is fully web-enabled, providing flexibility for monitoring and managing DR initiative without relying on special machines or phone calls. Niagara can utilize either the Internet or Intranet as its backbone, leveraging communication infrastructure already in place to provide access from any computer on the network using technologies such as SSL (Secure Sockets Layer) or a Virtual Private Network (VPN) to ensure security. In summary, Tridium's Niagara Framework delivers reliable technologies that connect utilities, grid operators, and energy consuming equipment in a facility to allow efficient management.

Specification for Hardware and Software

The Niagara Framework and customized software are realized using JACE controller hardware. Additionally, Tridium has developed several peripherals and legacy hardware for specific purposes. The current software is Niagara Framework with two legacy software programs (R2 and Sedona).

Niagara supports SSL to provide secure communications between a web browser and the station. SSL between the web browser and the Niagara station provides privacy, authentication, and message integrity over the Internet. HTTPS can be enabled from the web wervice in the Niagara station, if required.



Company Case Studies

Many successful applications of Niagara Framework in different industries and companies can be found in the library of the company's website. [35]

According to a case study on the partnership between 21st Century Tower in Dubai and Tridium, "The Tridium solution has provided us with a fully open, web-based system architecture which is easy to access and control." [36]

GameStop referred Niagara Framework as "a phenomenal product, able to scale quickly and easily, and priced well. When we work with global projects we want to make it as easy as we can." [37]

A quote from Jim Greif of Boeing on Tridium's solution, "I used Vykon to implement my energy saving strategy that won Boeing's 'Best Practice' award for energy management."[38] With Vykon energy management applications, Boeing conserved 18000 kilowatt hours on weekends and 10080 kilowatt hours on weekdays.[39]

By integrating Niagara Framework using system integrator ETAVIS, Tridium has provided Allianz an "instant, transparent, and responsive access and control over any sub-system via an online portal" and "a reliable, easy to access and integrated site-wide building management solution." [39]

36. 21st Century Tower, Tridium integrates controls on the world's tallest apartment block, Tridium.

37. Niagara Framework for Data Centers A Case Study: GameStop, 2014, Tridium.

38. Case Study Boeing presents internal "Best Practice" award for energy management applications; Vykon used to implement strategy, Tridium.

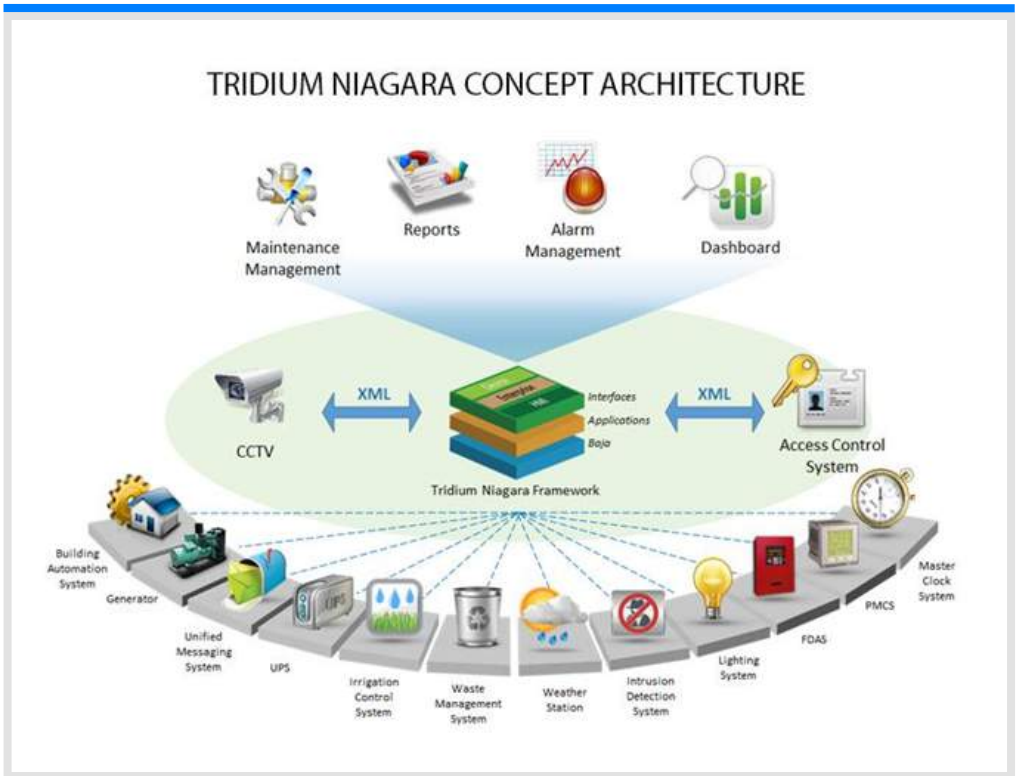
39. Allianz Suisse headquarters, Zurich Tridium's NIAGARA FrameworkTM brings unity to Allianz Suisse, Tridium,

Relative Strength in the Marketplace

Tridium's products are available to users in 77 countries around the world. Niagara Framework has worldwide appeal with 400,000 instances-including those from all major controls OEMs-for applications as diverse as airports, campuses, hospitals, schools, and homes. Tridium provides a selection of products and features for a wide variety of industrial purposes. As of 2016, the service has 13 versions of Niagara software and 7 versions of JACE hardware. The company claims that the Niagara Framework is found in nearly half a million instances worldwide, indicating its wide application and successful implementation. Tridium provides an open distribution system, which allows the customers to have easy access to many partners and distribution channels, including original equipment manufacturers, distributors, independent systems integrators, and other technology companies with local support. Additionally, Tridium has a library of case studies across a broad range of industries including building automation, data center, industrial, and government.

Future Developments

Tridium aims to connect minds and machines. Tridium's goal is to make Niagara a major global framework for integrating control and monitoring. Advancements of truly open environments and innovations in the IoT are the long-term development objective of Tridium.



SIEMENS

Company Description

SIEMENS

Siemens AG, headquartered in Berlin and Munich, is the largest engineering company in Europe, with 348,000 employees in 190 countries. Siemens' reported worldwide revenue of approximately $86.2 billion in 2015. In the U.S., Siemens reported revenue of $22.4 billion, including $5.5 billion in exports, and employs approximately 50,000 people throughout all 50 states and Puerto Rico. Siemens has approximately 75 manufacturing sites in the United States. The company invests more than $1 billion in research and development annually and more than $50 million in job training programs. As of 2016, Siemens earned $85.51 billion in revenue, had assets of $133.93 billion, and made profits of $6.46 billion.[40]

In July 2016, Riffyn, a company that provides cloud-based software for computer-aided process design and advanced data analytics to research and development organizations, announced an investment by Siemens venture capital to accelerate the launch of its cloud-based research process design software. While Siemens' portion is undisclosed, Riffyn's total funding was $4.6 million. [41]

In 2016, Siemens launched "next47" with a $1.1 billion investment for the next five years. Siemens aims to develop their business in areas like artificial intelligence, decentralized electrification, and IoT. The funds will be available to parties willing to pursue business ideas in fields strategic to Siemens' future. Offices for "next47" are planned for Berkeley, Shanghai, and Munich. From these key locations, it would have global coverage. [42]

40. How the U.S. Can Be a Leader in the Factory of the Future, June 4, 2015, The Wall Street Journal.

41. Siemens Investment Accelerates Launch of Riffyn's Ground-breaking R&D Design Software, July 6, 2016, Ryffin.

42. Siemens to invest $1.1 billion in new startups unit, June 28, 2016, Reuters UK.

Siemens' businesses are bundled into nine divisions: [43]

- **Power and Gas** – Offers products such as gas turbines, steam turbines, compressors, integrated power plant solutions, as well as instrumentation and control systems for power generation.
- **Wind Power and Renewables** – Manufactures and installs wind turbines for onshore and offshore applications.
- **Power Generation Services**
  Energy Management – Provides products, systems, solutions, software, and services for transmitting and distributing power as well as developing intelligent grid infrastructure.
- **Building Technologies** – Supplies automation technologies and services for buildings and infrastructures.
- **Mobility** – Encompasses businesses for passenger and freight transportation, rail automation systems, rail electrification systems, road traffic technology, and information technology solutions.
- **Digital Factory** – Deals with products and system solutions for automation technologies and industrial controls used in manufacturing industries.
- **Process Industries and Drives** – Sells converters, gears, motors, drives, and couplings.
- **Financial Services**
- **Healthcare Division (separately managed)** – Provides medical technology and software solutions as well as clinical consulting services.

Approach to IoT

Debjit Mukerji, Director of Venture Technology, Siemens TTB Berkeley, served on a panel, "Investor Outlook: Perspectives on the IoT Ecosystem" in 2015 and said, "The Internet of Things will impact all of our businesses, across our entire value chain — from design and engineering, to operations, to maintenance and value added services…IoT is one of the pillars of Siemens' Digitalization strategy and is centrally important to our technology future. Siemens has a unique opportunity to shape the future of IoT, being very close to real world applications and implementations of IoT solutions."

Siemens technology is intended to support manufacturing systems. The digital factory portfolio includes:

- **Automation systems** – SIMATIC industrial automation system comprised of Programmable controllers, Distributed I/Os, Programming devices, SIMATIC Software, Micro Automation

43. Forbes Global 2000 List, May 2016, Forbes.

Sets, Component Based Automation, Machine Vision (Sensors, Test and Measurement Technology)

- **Operator control and monitoring systems** – SIMATIC HMI offers flexible human machine interfaces

  Industrial controls – SIRIUS planning efficiency at various stages of a project
- **Industrial communication** – SIMATIC NET offers computer components such as, industrial Ethernet, PROFINET and PROFINET support, A-S interface, IO Link, KNX/EIB
- **PC-based automation** – Industrial PCs, PC-based controllers, ET 200SP Controller, embedded bundles with industrial PCs, software packages for SIMATIC PCs, industrial monitors and Thin clients, HMI devices for special requirements and hazardous areas
- **Motion control** – SIMOTION engineering system integrated with runtime software modules (motion control programming), and unique hardware platforms.

Technical Specifications

Smart manufacturing is sometimes called advanced manufacturing and involves the use of innovative technology to improve products or processes. Such manufacturing is native to smart factories that use innovative technologies.

Siemens offers a broad range of state-of-the-art products and solutions for advanced manufacturing. These products are involved in many operations throughout the world including space exploration, energy management, food and beverage services, and vehicle manufacturing. Principal technologies include:

- **SIMATIC IT Manufacturing Execution System (MES)** – A scalable IT system that guarantees overall component integration and ensures product optimization across global facilities.
- **COMOS plant engineering and industrial software** – Enables customers to design and manage the assets of plants holistically throughout their lifecycle.
- **Siemens PLM Software** – A provider of product lifecycle management (PLM) industrial software.
- **Totally Integrated Automation (TIA)** – Sets benchmarks in production optimization (production planning and production engineering) and is aligned towards customer's requirements and international market trends.
- **Totally Integrated Automation (TIA) Portal** – An engineering production framework for integrated automation.

Company Case Studies

Siemens UK reports the following case studies: [44]

2015:

Siemens fan upgrade at Hanson Purfleet saves energy and reduces carbon footprint: A fan upgrade by Siemens UK & Ireland at Hanson Cement's highly productive Purfleet plant has resulted in energy savings of more than 36 percent, with payback on the investment anticipated to be well under two years.

2014:

Lafarge - Safety first: Adhering to legislative requirements is an essential part of modern production processes, in particular to ensure a safe working environment for employees. With this in mind, Siemens Industry worked with Lafarge Tarmac at its Tunstead Cement Plant during a modernization project to provide independent consultancy support to the site's in-house engineering team and help ensure compliance with the safety-led requirements of the Machinery Directive 2006/42/EC.

Energy Efficiency - Manufacturing plant sees the lights of efficiencies: The improvements, undertaken as part of the Siemens Energy Efficiency Programme (EEP), has involved the upgrade of the site's lighting infrastructure, and the replacement of poorly performing and aging lighting and electrical cabling with the installation of 216 light fittings made up of four high efficiency lamps per fitting. They are designed to deliver improved energy efficiencies, a better working environment for staff, and optimized flexibility in lighting control.

Printing Firm Tackles Pressing Energy Issues: Major gravure printing firm Prinovis UK Limited benefits from energy savings, reduced costs and increased operational efficiencies thanks to a Siemens Industry energy reduction project initiated by Prinovis.

Relative strength in the Marketplace

The IoT Institute recently published a list of the 20 most important IoT firms as rated by an audience of end-users. [45] The audience consisted of members from manufacturing, agriculture, and government. Siemens was ranked as seven with 18 percent of votes.[46]

The many industries in which Siemens' products are used make it difficult to pinpoint the extent of Siemens operations. For example, according to PR Newswire, "The major companies operating in the global IoT market in structure monitoring market include ABB Ltd., Siemens AG, Schneider Electric SE, Cisco Systems Inc., Delta Controls, Accenture, General Electric, IBM Corporation, Honeywell International Inc. and Johnson Controls Inc.," however, this does not reflect Siemens' involvement in other industries. [46] It is fair to say, given the financials, that Siemens is a significant character in the IOT landscape.

44. Siemens Case Studies, Siemens.

45. The 20 Most Important IoT Firms according to You, April 23, 2016, Internet of Things Institute.

46. Global IoT Market in Structure Monitoring to Witness 24.1% CAGR During 2016 - 2022: P&S Market Research, July 7, 2016, PR Newswire.

Future Strength and Opportunities

Siemens is developing the concept of "closed-loop manufacturing" that involves bidirectional data flow between development and engineering. For example, a recent article posted in Electronics Weekly discusses Siemens' Industrie 4.0 (smart factory) strategy, which involved the acquisition of a supplier of simulation software for fluid dynamics (CFD), solid mechanics (CSM), heat transfer, particle dynamics, reactant flow, electrochemistry, acoustics, and rheology. [47] Siemens has also created a cloud storage and analysis environment for industrial automation that offers industrial users an open infrastructure, enabling innovative digital services.

CISCO

Cisco Systems, Inc. (Cisco), incorporated in 1984, delivers integrated solutions to develop and connect networks around the world. Cisco operates globally, with a focus on the following areas: Americas; Europe, the Middle East, and Africa (EMEA), and Asia Pacific, Japan and China (APJC). The company has made significant investments in the Internet of Things, and will focus on developing their offerings moving forward.

Approach to IoT

Cisco implements the concept of the IoT by using its hardware and software. Cisco's IoT system has also helped companies reduce cost and increase productivity. For example, SeeBerger is a manufacturing company located in Germany. [48] SeeBerger's business expanded and they required complete control of their production process, so they turned to Cisco IoT solutions. Cisco's solutions brought major changes to SeeBerger's production process, for example, warehouse operations are now integrated and automated. The production requires less space for supplies and, therefore, creates more room for new machines. Automated operations bring changes, such as wirelessly linked orders, production, storage, and DTVs. In order to prevent any breach in security, data and applications are protected by Cisco firewalls. In short, Seeberger's automation process opened new opportunities for further business growth.

Cisco's IoT system has also addressed problems in various sectors, including oil and gas, transportation, mining, and manufacturing.[49] Cisco's IoT system is based on six pillars:[51]

1. Network connectivity
2. Fog computing
3. Data analytics
4. Security (cyber and physical)
5. Management and automation
6. Application enablement platform

47. Siemens makes IoT relevant to smart factories, May 2, 2016, Electronics Weekly.

48. Warehouse of the future, 2015, Cisco.

49. Cisco IoT System, 2015, Cisco.

Cisco also provides consulting for IoT services. They collaborate with technology partners to help companies to design and implement IoT solutions.

The Cisco IoT product portfolio comes with the following services:[51]

- Cisco architectural roadmap
- Cisco micro-engagement and starter kits
- Cisco design and build service
- Cisco solution optimization service
- Cisco product support services

Technical specifications regarding Cisco IoT products and technology

Cisco's IoT system is based on a stable networking infrastructure. IoT applications should support low latency and should be resilient against security threats. Cisco's IoT system operates on both a wired and wireless network infrastructure. Cisco has a broad selection of reliable and scalable routing, switching, and wireless products and software-only solutions that can be integrated with third-party devices. Cisco IoT network connectivity offers the following advantages:[50]

- It is resilient to scale, so companies can expand their IoT infrastructure and add more capability to its existing system with ease. It helps companies meet the need for expansive networking infrastructure without making any major changes to their existing infrastructure.
- Cisco's network infrastructure adds integrated security so that it can prevent breaches in security. In addition, Cisco IoT system supports IT and OT standards and protocol and helps companies converge IT and OT networks to connect existing and new IoT applications.[4]

In the IoT, sensor data is collected from various edge points and later accumulated to a cloud for further analysis. Since millions of devices are connected to an IoT infrastructure, it can easily create bandwidth, latency, and security problems. [51] Cisco Fog data service resolves all those problems and acts at the edge of the network. It analyzes data and transmits less time-sensitive data to the cloud. Cisco's fog data services support the following:[52]

- Filtering of data based on metadata and payload content
- Intelligent encryption of plain text sensor data
- Remote, zero-touch configuration of devices through REST APIs
- Local caching based on dynamic time and size
- Aggregation and detection of events

Cisco's IoT fog data services help customers get control of sensor data and analyze it with efficiently. Customers can perform analytics at the network edge. Fog data service supports encryption of plain text and anonymity of selective data which gives customers the necessary support for privacy and security of sensor data.[53] Moreover they can also apply rules and regulations to filter sensor data. For example, sensor data can be used to collect temperature information from network edge

50. Build Highly Secure IoT Network Connectivity, 2016, Cisco

51. Cisco IoT Systems, 2015, Cisco

52. Cisco Fog Data Services, Cisco.

and later apply fog data service rules and regulations to determine which temperature data is above a certain threshold. If it is above a certain threshold, it will transfer the data to cloud.

In the IoT, many devices communicate with each other. Since more and more devices are connected to the existing infrastructure, the risk of cyber threats increases. Cisco defends against this problem by combining compressive physical and cyber security solutions. Security is a major concern for companies since a security breach can be very expensive. Because of this, Cisco puts an emphasis on IoT security and has implemented robust physical and cyber security solutions.

Cisco also applies IoT physical security policy to prevent any potential cyber attack. Cisco's own hardware devices, such as surveillance cameras, physical access control, and motion detection can provide useful information. Those cameras are equipped with wide dynamic range (WDR) technology that allows them to take pictures even when illumination levels vary.

Cisco also provides the following professional services and collaborates with ecosystems to prevent hacking or cyber threats:

- Industrial Cyber Security Capability Assessment
- Industrial Cyber Security Reference Architecture
- Industrial Cyber Security Plan, Design, and
- Implementation
- IoT Physical Security Services

Cisco's management and automation solutions offer control and provide support for Cisco's IoT system. [53]

Specific information on whether Cisco is offering a hardware solution, software solution or combination of both

Cisco's approach to IoT is a combination of both hardware and software solutions. It addition, Cisco have Cloud Connect which is the Cisco mobility-based cloud software suite.[54] This software suite is helpful for mobile operators since it offers a complete solution for IoT experience.

Company Case Studies

Cisco's IoT solutions have been successfully implemented by many industries. Below we have provided a summary of successful deployment of IoT solutions.

Stanley Black & Decker:

Stanley Black & Decker, Inc. is a manufacturing company based in Reynosa, Mexico and has more than 52,000 employees.[55] The company produces hand tools, power tools, mechanical access solutions, electronic security, monitoring systems, and products and services for industrial applications. The company wanted greater control over its large-sale manufacturing process. In short, the company wanted to meet the following goals:

53. Get Comprehensive IT and OT Management, 2016, Cisco

54. Cisco IoT Cloud Connect, 2016, Cisco

55. Leading Tools Manufacturer Transforms Operations with IoT, 2014, Cisco.o.

- Reduction of labor cost
- Clear visibility and understanding of effects of shift changes and resource changes
- Transparency of the schedule and production output
- Equipment effectiveness, line productivity, and reducing production line changes

To meet these goals, Stanley Black & Decker turned to Cisco and AeroScout. Cisco's wireless solution and AeroScout's industrial solution helped Stanley Black & Decker become a fully connected production line with Real-Time Location System. Real-Time Location System includes RFID tags that were deployed to materials, which provide real-time data to assembly workers and production managers. Since the company already has a robust wireless networking infrastructure, management used Cisco access points to their advantage. This solution helped production managers get mobile access to production line information. In addition, visual and executable dashboards were deployed to keep production managers informed up-to-the-minute.

Five inventory lines were connected by RFID tags, which provide valuable information to managers, and it helps them to determine whether there were any obstacles, employee performance, and whether production met the daily requirements.

The outcome was impressive. Overall equipment effectiveness increased by 24 percent. Stanley Black & Decker's Reynosa plant was able to control over-inventory and was able to decrease inventory costs. Since the inventory process became more visible, Stanley Black & Decker has been able to offer better customer service. The company has achieved 10 percent greater labor efficiency and the utilization rate increased from 80 to 90 percent. [56]

The devices used for this implementation:[57]

Routing and Switching

- Cisco 2911 Integrated Services Router
- Cisco Catalyst® 3750 Series Switches

Wireless

- Cisco Unified Wireless
- Cisco Aironet® 1200 Series Access Points

Partner Products

- AeroScout MobileView Software
- AeroScout Wi-Fi Active RFID Tags

BC Hydro

BC Hydro is the main electric distributor in British Columbia. BC Hydro provides safe and clean energy to residential, commercial, and industrial customers.[57] Population is increasing gradually and the demand for power is increasing as well. BC Hydro required a scalable infrastructure that meets this rising demand. They wanted to meet the following goals:

- Providing great and reliable services
- Capability of remote automation and monitoring
- A common networking infrastructure for applications

56. Internet of Things Case Study: Stanley Black & Decker, Cisco.

57. A foundation for improved protection and automation, 2015, Cisco.

BC Hydro needed to provide fast customer support and required an infrastructure that could meet their growing needs.

To resolve these problems, BC Hydro focused on building a smart grid architecture. The design was based on Cisco FAN architecture, which is an IP-based communications architecture and supports network connectivity between field devices. The connectivity between devices provides more real-time data and BC Hydro plans to migrate to the Cisco IOx software platform, which will offer more flexibility over distribution automation. BC hydro has also implemented smart meters. A smart meter automatically sends hourly interval usage data twice a day. It gives more visibility to customers, and to BC Hydro, so electrical problems can be easily identified. The new system allows BC Hydro to quickly isolate any power fault quickly and the new system has increased the safety of their customers.

The new system offers the following advantages:

- BC Hydro is collecting usage data at regular intervals so BC hydro is getting more information about power usage.
- The new system allows more control on power outages.
- Remote devices have been used throughout the grid to provide more visibility

The following Cisco solutions have been used in this project:[58]

- Designed a smart grid based on Cisco Field Area Network architecture and advanced metering infrastructure (AMI).
- Deployed Cisco Identity Services Engine and Cisco connected firewalls, mobile devices, and systems
- Cisco IoT Planning, Design and Implementation (PDI) Advanced Services, and Cisco IoT Network Optimization (NOS) Advanced Services

58. Customer Stories, Cisco.

Relative strength in the Marketplace

Cisco has a number of clients worldwide and it is growing rapidly. Cisco has worked with many different companies around the world and helped them achieve industrial automation. Cisco provides IoT services in sectors such as automotive, manufacturing, government, public sector, and more, helping companies' production lines become faster and more efficient. [58]

In order to strengthen their existing IoT system, Cisco has recently acquired Jasper, whose IoT services are used by 3500 customers in more than 100 different countries. [59]

Cisco has been putting an emphasis on security vulnerabilities, since it's a major concern for companies. According to Mike Weston, the Vice President of Cisco Middle East, that Cisco will be mainly focusing on the next generation of security solutions.[60] Since IoT will be playing an important role in future, security vulnerabilities will become a big concern as more networking and wireless devices collaborate. Cisco's integrated thread defense strategy is ready to face challenges in cyber security.

Weston also mentioned that the Cisco Digital Ceiling, which lowers the cost of building maintenance, would be next frontier in the IoT.[62] The Cisco Digital Ceiling accelerates digital transformation and is becoming a central platform for business transformation. [61] It converges multiple building networks, lighting, heating, and cooling, IP video, IoT sensors, and more, through a secure and intelligent network platform. Analytics and software run in Ceiling and sensors can adjust and enhance facilities in real-time, without human intervention, lowering the operating costs of facilities.

Additionally, Weston has mentioned in his blog that the IoT would be the next driving force in industrial, manufacturing, public transportation, residential, and other sectors.

The following two paragraphs highlight Cisco's vision and strategy for IoT: [62]

> *"Digitization/Internet of Everything Globally, countries, cities, industries and businesses are becoming digital to capitalize on the next wave of the Internet - the Internet of Everything (IoE), which we define as the connection of people, processes, data and things. When people, processes, data, and things are connected, we believe it creates an opportunity to deliver better customer experiences, create new revenue streams and operating models to drive efficiency and produce value. Our goal is to be a strategic partner to our customers by providing the solutions, people, partners, and experience as our customers move from traditional to digital businesses. We believe our customers' journey to becoming digital businesses requires security, cloud, mobile, social and*

58. Customer Stories, Cisco.
59. Cisco Completes Jasper Acquisition, March 22, 2016, Cisco.
60. Spotlight on Cisco's IoT and Security Solutions at Future Technology Week 2016, 2016, Cisco.
61. A Digital Ceiling Is Now a Business Imperative, August 2016, ZK Research.
62. Cisco Systems, Inc. 2015 Annual Report, 2015, Cisco.

analytic technologies with a strong foundation of an intelligent network that is agile, simple, and that provides real time business insight. The move to digital is driving many of our customers to adopt entirely new IT architectures and organization structures. In our view, we are delivering the architectural approach and solution-based results to help them reduce complexity, accelerate and grow, and manage risk in a world that is increasingly virtualized, application centric, cloud-based, analytics-driven, and mobile."

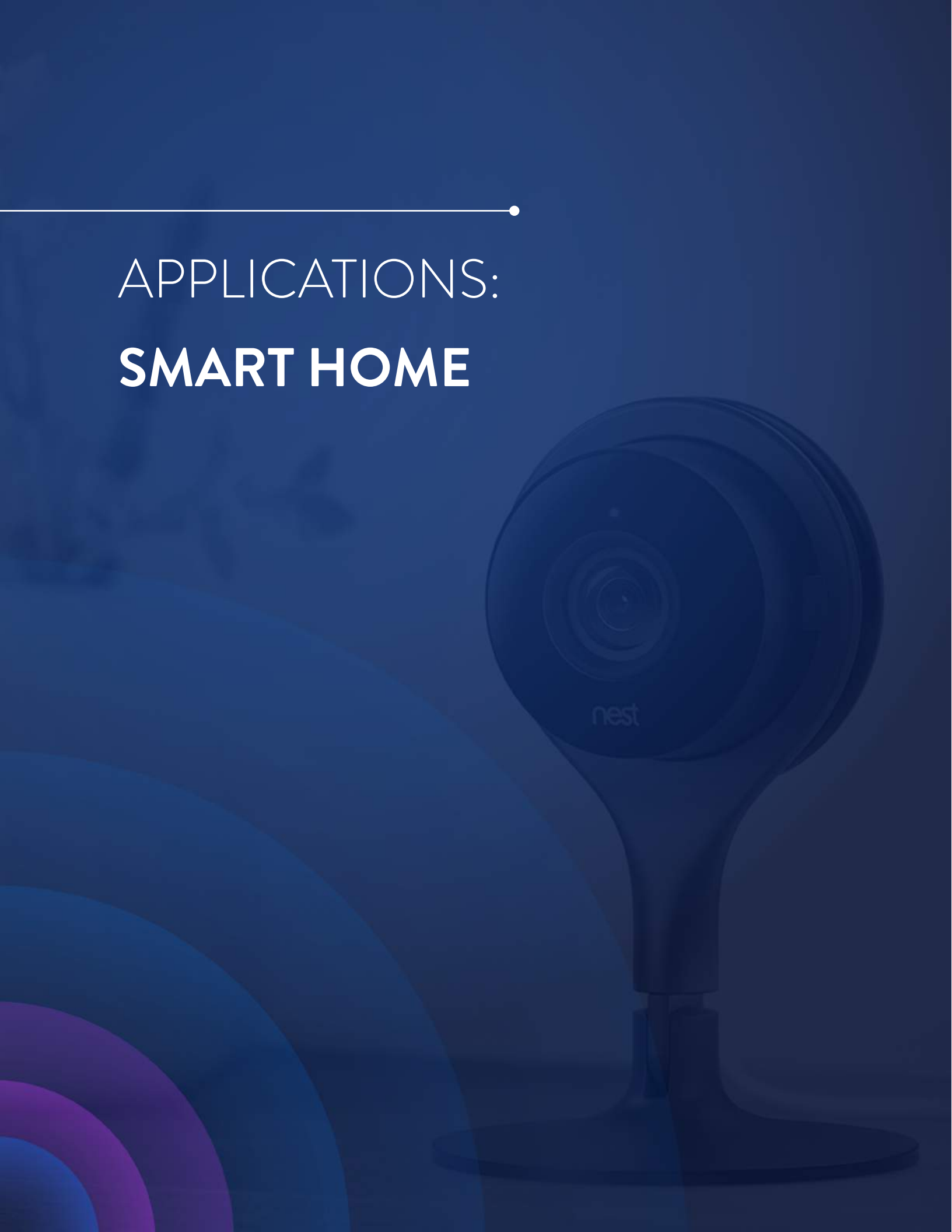
"The connection between our portfolio of cloud offerings and the IT consumption model of the future, and our ability to replicate our cloud offering approach across our entire product portfolio and thereby to both enable customers to accelerate their digitization journey and to differentiate our leadership in the Internet of Everything; our acquisition strategy of buy, build, partner and invest, and the degree to which that strategy will help us capitalize on market transitions and maintain leadership in our current business areas; increasing the percentage of software and subscription related revenue within our overall sales mix; the intelligent network as being at the center of every market transition and our leadership in markets related to the network; our efforts to establish an unbeatable position in the market and the possibility of our achieving our aim of becoming the number one IT company; and other characterizations of future events or circumstances"

MAIN PLAYERS

The IoT in the manufacturing ecosystem consists of several types of players. These categories are listed below, with some examples of the main players operating within this space:

Software Vendors	IBM, BOSCH, ZEBRA
Security Service Providers	intel, Symantec, TREND MICRO
System Integrators	CSC, IBM, SIEMENS
Platform Providers	IBM, Microsoft, SAP
Network Providers	ZEBRA, IBM
Device Manufacturers	CISCO, SIEMENS

APPLICATIONS:
SMART HOME



Smart Home

Smart doors/locks/garage doors/security systems

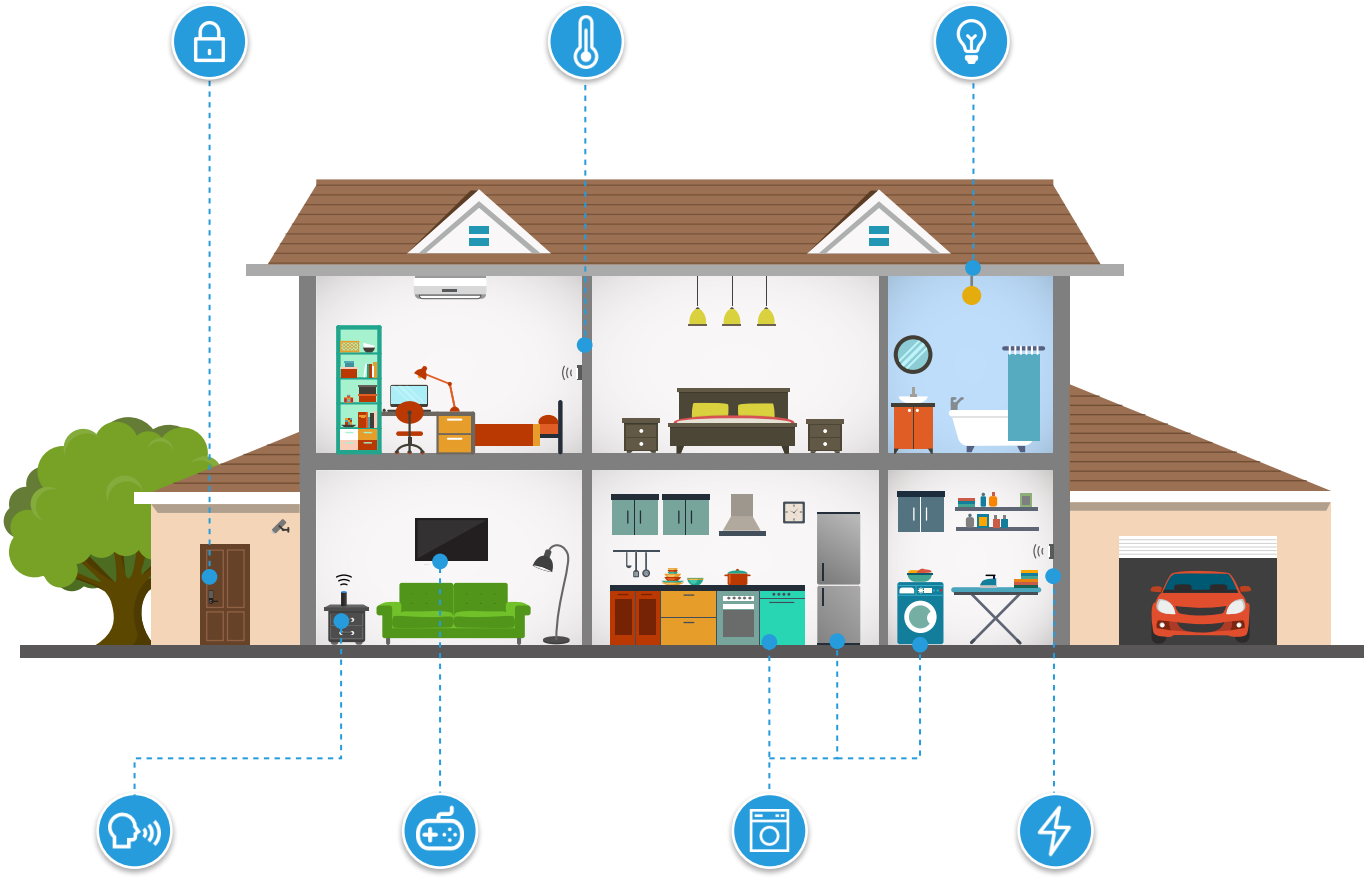
Remotely control access to your home and monitor what is going on through any mobile device from anywhere

Temperature and humidity sensors

Temperature and humidity sensors automatically adjust your home's settings according to external factors and personal preferences throughout the day

Smart lighting

Smart lighting added throughout your house leads to energy efficiency and a home lit to your exact perferences



Personal assistant device (Amazon echo-like)

Personal assitstants will facilitate interaction with all connected devices by complementing technology with AI

Smart entertainment systems

Smart entertainment systems provide full control over comfort and entertainment choices

Smart appliances (refrigerator, TV, washing machine, dishwasher)

Smart appliances will speak to each other, be more energy eficient, automate your chores, and reduce your workload

External electric adapters

These adaptors measure and optimize energy usage for all electronic devices. By facilitating M2M communiaction, they also allow for increased device functionality

MARKET INFO

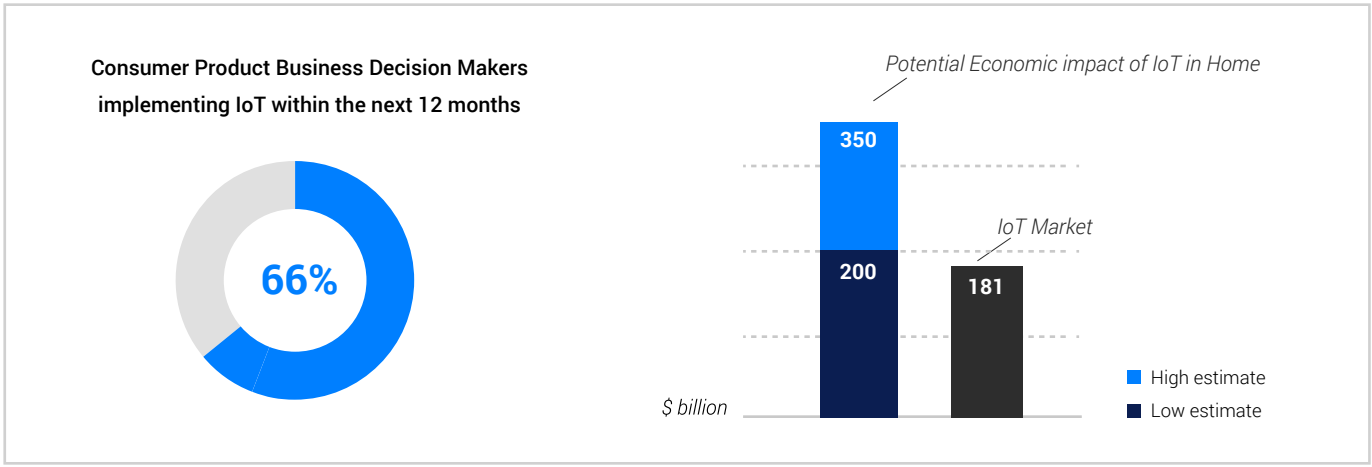
The developments of the IoT that have garnered the most media attention are the use of networked devices and appliances to turn residences into "smart homes." These smart homes use the integration of devices to control the indoor environment, and to increase safety and energy efficiency.

According to a 2016 report from Mind Commerce, this industry will grow to $133 billion by 2021, with a CAGR of 27.2 percent.[63] Additionally, a 2014 report from Esearch and markets estimates the smart buildings market to grow from $110.9 billion in 2014 to $181.1 billion 2020, with physical security, lighting control, fire detection, and safety representing the 3 largest segments.

The smart home ecosystem is rapidly expanding and includes:

- **Home and Office Equipment** – Printer, VoIP Phone
- **Connected Entertainment** – TV, Receiver, DVD Recorder, Media Player, Gaming Consoles
- **Personal Consumer Electronics** – Wireless IP Camera, Smartphone, Tablet, Portable Media Players, Navigation Devices
- **Energy Management** – Temperature, Lighting, Heating and Air Conditioning
- **Safety, and Smart Consumer Appliances** – Washing Machine, Refrigerator

According to Compass Intelligence, "The Connected Homes marketplace has been slow, but steady, building a firm base of support towards a projected high growth trajectory starting in 2018." The industry is projected to overcome several growth inhibitors, including gateway interoperability, lack of true device plug-and-play, and concerns over privacy and security (and the lack of communication to end-users about policies, procedures, and data-safe devices and systems), within two years.



Left, Industry decision makers insight into IoT [68]. Right, Estimated potential impact of IoT applications by 2025 (Low estimate - dark blue, High Estimate - light blue)[69] and IoT market size by 2020.

63. http://www.mindcommerce.com

WHAT IS A SMART HOME? WHAT DOES IT ENABLE?

Imagine arriving home in the evening and your home wakes up to welcome you. The garage door opens after authenticating your identity and the lights switch on. The blinds open to expose the amazing view, and the temperature is pre-cooled 30 minutes prior to your arrival to a pleasant 78° F even in the hot Southern California weather. As you walk into the living room, a preset scene is activated to your preferences, warm soft light for dinner and a relaxing evening. When you finish dinner and start watching a movie, the lights dim automatically. Halfway through the movie, someone rings the doorbell, and you pause it. The lights fade on gently as you check on the live video feed on your phone and you see that your neighbor has come by with dessert. Later in the evening, you go to bed while your home dims off the lights and adjusts the AC as the outside temperature cools. When you wake up the next morning, your coffee is ready. As you're driving to work, you can't remember whether you turned off the coffee maker, so you check your phone to see that it's off. You have also checked and seen that your AC is off and set to turn on shortly before you arrive home in the evening and that the garage door is securely locked. You can also see a reminder to grab eggs at the grocery store, because you're running low. While you're at the store, your home can tell you're grocery shopping and has delayed turning on the AC to help save money on the utility bill.

This is not a dream of the future, nor does it require a butler named Alfred. It's already a reality with the ever-growing intelligent technology in the marketplace. In 2015, the annual revenue from residential smart devices was estimated to be around $7.3 billion, and it is projected to grow nine-fold to $67.7 billion by 2025.[64] Indeed, many appliances in our homes could benefit from being "smarter," and today many products are available. For example, Belkin's WeMo home automation branch has collaborated with a number of coffee machine manufacturers to sell a smart coffee pot that is linked to the alarm clock. Nest and Honeywell have been selling smart thermostat and home HVAC systems that "know" your temperature preference throughout the day and year and "know" whether you're home or away. Quirky, a company that provides a platform to connect inventors to the mass market, is selling an egg-tray that knows how many eggs you have left. Chamberlain and LiftMaster, two of the industry leaders in garage openers, have been selling smart garage door openers and security alarm systems and

64. Global Revenue from Shipments of Residential Internet of Things Devices Is Expected to Reach Nearly $70 Billion in 2025, Navigant Research.

there are a number of companies selling automated blinds, such as Somfy systems, Bali Blinds, and others.

As appliances and devices gain more intelligence, consumers also crave an effortless and elegant way to control them, with a smooth and natural user experience. Sensing this demand, a number of companies have risen to the challenge and started selling products that tie various smart devices together into a coherent, cooperative system. For example, companies such as Samsung's SmartThings, Amazon, and GE's Wink have made smart home hubs that create a unified interface for users to control their entire home in one place. Certain devices such as Amazon's Alexa even allow natural interaction using voice control, and the experience is nothing short of what one would expect from a sci-fi movie, where you can simply tell your home to do things on its own. The future has arrived.

Some may think that some of these "features" were achievable using timer switches already. However, the true beauty of this ecosystem only takes form as we continue putting more computer powered intelligence and data connection into everyday items. We are opening up the possibility to use programming and artificial intelligence to control those devices, to make them talk to each other, and work with each other. People in the future will probably be shocked that we had to manually do things like stocking the pantry and making a shopping list, or driving back home to make sure the door is locked.

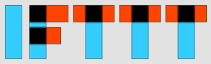
The evolution doesn't stop there. As we connect everyday items to the Internet and allow them to communicate, one thing becomes abundant: data. Particularly, data that reveals consumer activities and preferences. This creates a huge impact for and benefit to manufacturers and service providers. For example, a smart TV can collect personal viewing habits to help "customize your viewing experience" but is also valuable for the entertainment industry to know what shows get the most viewership in order to maximize advertising revenue. Data from a smart thermostat can help utility companies better understand user demand and optimize energy generation to be more cost effective. A smart gadget can help a company further reduce cost if they know how many times it will be used during the warranty period. Smart devices in the kitchen can provide data to create predictive grocery lists that can also feed anonymous demand data to supermarkets, which can then use the data to better schedule inventory. Data has an almost unlimited value to every industry, providing insights and opportunities to analyze behaviors and consumption patterns. This can be used in all aspects of business, from manufacturing and inventory to advertising and marketing.

The revolution to make smarter homes presents unlimited opportunities to improve consumers' comfort, convenience, and enrich their lives. At the same time, it provides manufacturers and retailers with new tools and channels to better understand their customers, provide better products, and improve efficiency.

KEY TECHNOLOGIES

In this next section, we will illustrate the state of the industry by highlighting developments occurring from some of the biggest firms vying for market share in this space. The focus is on technology offerings, market share, and business strategy and direction to highlight where the industry is going.

IF THIS THEN THAT



If This Then That (IFTTT) is a free web-based service that attempts to connect Internet services with each other and with the increasingly popular connected IoT household products. Launched in 2011 in San Francisco, this service was created by Linden Tibbets, Jesse Tane, Scott Tong, and Alexander Tibbets. It is available through its website and apps for iOS and Android. In 2014, the company was valued at approximately $170 million. The company operates using funding from venture capitalists ($30 million in Series B funding in 2014) as well as revenue from "service providers." These are device makers and online service providers who want their users to have the ability to customize automation.

Approach to IoT

These web-based services revolve around the concept of "recipes" or chains of simple conditional statements that can be triggered based on various Internet connected products or services. For example, online services such as Gmail, Facebook, Instagram, Pinterest, Weather Channel, Google Drive, Amazon Alexa, and Twitter can be used to trigger recipes in the IFTTT system when they are set up as channels. IFTTT also works with various home automation solutions such as the SmartThings hub, Philips Hue lights, LIFX bulbs, Belkin WeMo switch, and others.

With the relatively simple structure, users can easily create "recipes" that complete certain tasks to automate their day.

Sample recipes:

- If SmartThings detects moisture, then call user's phone with a predefined message
- If category 1 hurricane winds are nearby, then tell SmartThings siren to strobe (or Philips Hue bulb to strobe)
- If it rains, then turn on a light
- If a photo is shared on Facebook, then share the photo to Instagram
- If you are mentioned in a Tweet, then flash the Hue light
- If a phone is lost, then call it with a long press of the WeMo light switch

These examples illustrate one important aspect of IFTTT, many of each product's automation functions are built-in (for example, the location-aware switching on or off of lights), but not many have the ability to cooperate with other products, let alone with online services. IFTTT fills that gap between devices and the numerous Internet services. An IoT home hub provides users one central place to control and orchestrate home devices. IFTTT takes it one step further, to not just to orchestrate within the house, but the online world of the user.

Technical Specifications

IFTTT employs a simplistic framework. Each product, be it a physical or an online service, can be represented as a channel on the platform. Channels are the basic building blocks of IFTTT. Each channel offers a collection of triggers and actions. Triggers (the "this" in a recipe) are events that are generated from online services or products that activate an action in a recipe. For example, a notification is created by a Nest thermostat motion sensor that detects movement, which then triggers another action. A notification can be created by a keyword that reads the weather report on a 15-minute interval to watch for rain or other precipitation, as an example. Similarly, a notification can be created if incoming mail is detected. Actions (the "that" in a recipe) are outputs that result from the trigger. For example, turning on a light or backing up a file. A recipe is simply a conditional statement connecting the two.

In addition to "if" recipes, which are conditional statements, IFTTT also offer "do" recipes, which are "smart toggles" from your smartphone that get triggered when a button is pressed.

Specification for Hardware and Software

IFTTT can be accessed through its website or iOS and Android apps. The service appears to run on Amazon Web Service and utilizes Apache Kafka for handling data streams generated by the triggers and message handling to the various channels.

IFTTT implements platform security by protecting and encrypting transmitted and stored data with SSL. However, the platform still uses a basic User ID and Password login and has not yet implemented any form of two-factor authentication.

Relative Strength in the Marketplace

IFTTT is available to users around the world. Some users might not be able to use certain channels due to regional restrictions (such as China blocking Facebook and Twitter). The company has not disclosed user statistics, except that there were 14 million personal recipes as of 2014. The company has not disclosed average user statistics such as average number of recipe per user.

IFTTT is completely free to users. Additionally, the simplistic nature of conditional statements makes it easy to start customizing automation routines. The service is also compatible with many products and services.

As of 2016, the service has 314 channels, including physical products such as:

- **Smartphones** – From battery management channel to location services
- **Services** – Such as Amazon Alexa
- **Google Services** – Such as calendar, contacts, and photos
- **Smart Home Products** – Such as the Honeywell thermostat, Nest, Philips Hue, Smart Locks, Samsung appliances.

- **Blogging services**
- **Business related services** – Such as Salesforce, Square payment system, LinkedIn, OneDrive, and Stocks
- **Commerce** – Such as eBay, Craigslist, and Home Depot
- **Connected car** – BMW, Automatic
- **DIY electronics**
- **Wearables** – Fitbit, Jawbone, and Nike
- **News sites**
- **Photo hosting sites, productivity apps** – Such as Dropbox and Todoist
- **Security** – Such as Nest Cam, iSmartAlarm, Scout Alarm and
- **Social networking** – Such as Facebook, Twitter and Pinterest

The flexibility and wide compatibility attract strong usage and attracts new users every day. In 2014, the company stated that 14 million personal recipes had been made on the platform.

Future Developments

IFTTT is continuously being improved and developed. The programming structure keeps evolving to make it more efficient, and the company is working with more hardware developers to bring new devices to the platform.

NEST (GOOGLE)

Nest Labs was founded by two former Apple engineers. Nest started selling a smart thermostat, and subsequently added a smoke and carbon monoxide detector and a security camera to the company's product portfolio. Nest Labs became a subsidiary of Google in 2014. The company announced in 2013 the Nest smoke and CO detector and a home surveillance camera in 2014.

Approach to IoT

The first product from the company was the Nest thermostat. The thermostat is a programmable, self-learning, sensor-driven, Wi-Fi-enabled thermostat with a touchscreen and an attractive user interface. The Nest thermostat optimizes the heating and cooling process of homes and business in the most energy efficient way. Based on a machine-learning algorithm where the system can observe user input during the initial weeks and use it as a reference data set, the system learns people's schedules and temperature preferences. The algorithm updates with new user input to adjust for new schedules, and the algorithm also combines data with the built in motion sensor so that it "knows" whether there are people in the room.

The company's motivation is to reinvent the thermostat to become something that's more than a simple on-off switch. The founders believe that with the advent of technology and connectivity appliances should be able to learn user habits and automatically adjust to suit the user with fewer and fewer human inputs. The approach is simple. With Nest's first product, the thermostat, instead of a switch with a predefined temperature, they made it capable of learning users' schedules and habits on an ongoing basis to optimize temperature accordingly and conserve energy.

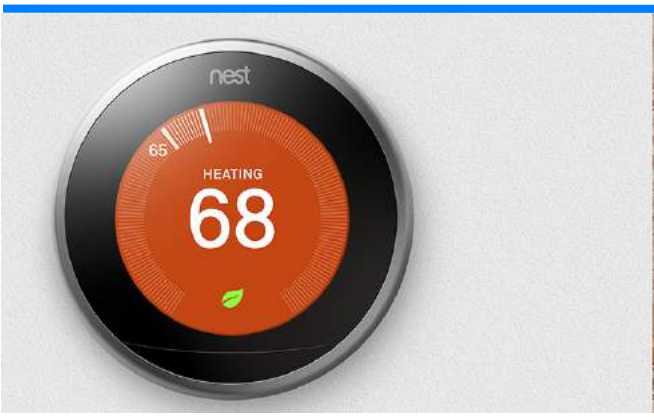
Another of Nest's products, the Nest Protect, a smoke and carbon monoxide detector follows the same principle. Nest Labs reimagined their smoke detector to be capable of sensing more. It has better detection hardware for smoke and carbon monoxide to identify the type of fire. It also has a motion sensor allowing users to use gestures to control it, as well as extending the proximity detection of the thermostat.

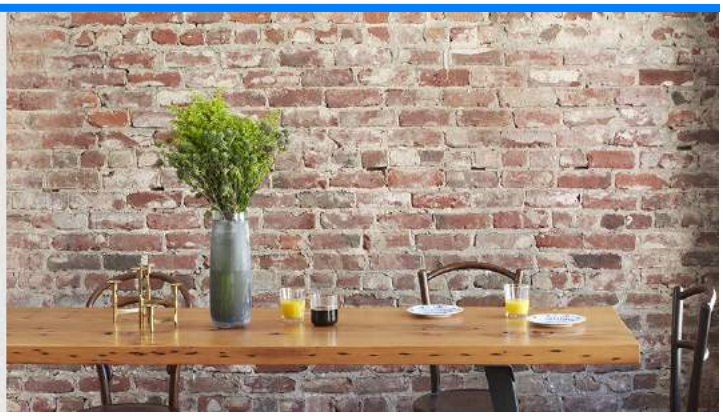
Their latest product, the Nest Cam, further extends the ecosystem's functionality by working with the thermostat and smoke detector to automate video recording, as well as utilizing the home and away functionality for security monitoring.

Technical Specifications

The Nest thermostat consists of a touch screen display with a rotating ring and the circuit board, and a base where the connection terminals are located. The Nest thermostat uses a UI where the main interaction is touching and rotating. The display shows heating and cooling temperature, energy history, scheduling, and other settings. The operating system is based on Linux 2.6.37 and uses many other free software components. The thermostat uses Wi-Fi to connect with the Internet and smartphones, and uses a protocol called Weave.

The Nest Protect smoke and carbon monoxide detector is a Wi-Fi-enabled, voice-activated detector. Protect also contains a light and a motion detector to provide a night-light feature and accompanies the Nest thermostat by serving as a motion detector in a second room. In case of fire, the detector can also turn off the furnace.





Relative Strength in the Marketplace

The Nest is available in the U.S., Canada, U.K., Belgium, France, Ireland, and the Netherlands. While there are no official sales figures, a recall by Nest Labs in 2014 recalled 440,000 smoke detectors in the United States alone.[65] A 2013 report claims that Nest was shipping 40,000 to 50,000 units per month. [66]

Nest has made its product compatible with other smart home products by sharing certain data and allowing a certain degree of control with other products and software ecosystems through their API.

The list of products compatible with Nest include:

- **Temperature and comfort products** – Keen Home Smart Vent, Big Ass Fans
- **Connected LED bulbs** – Philips Hue, LIFX, Lutron, Insteon, Osram
- **Smart Locks** – August, Chamberlain, Kevo, Haven
- **Home appliances** – Whirlpool washers and dryers, LG appliances
- **Wearables** – Pebble smartwatch, Jawbone Up
- **Cars** – Mercedes Benz, Automatic (an adapter for communicating with modern cars), ChargePoint charging station for EV
- **Other home gadgets** – Ooma phone, Withings Aura alarm clock, Logitech Harmony (a universal remote control), ivee Sleek, Scout home alarm products, Zuli smartplugs, Sense Mother (various types of sensors for home automation), Wink home automation products
- **Apps** – Life360 (a Facebook type app for family), Google Now

Nest was acquired by Google in 2014 for $3.2 billion, and is now a subsidiary of Alphabet Inc., alongside Google. Google acquired the camera startup Dropcam in mid 2014. Nest acquired Revolv, a company making another smart home hub, in 2014. Nest closed down Revolv and permanently disabled the Revolv hub service and app on May 15, 2016. Nest has also previously acquired the energy data service company MyEnergy in 2013, and shut down their service in 2016.

Company Case Studies

Nest published a white paper with its case study of the effectiveness of Nest Thermostat on energy savings. The study found that the Nest thermostat creates about 10 percent to 12 percent heating usage saving and about 15 percent cooling usage saving. The study sample energy data from 624 homes using electric heat and 735 homes using gas heat. The study uses the panel data to perform weather normalized energy usage and compared pre- and post-installation energy usage using regression analysis.

65. Recall by Google's Nest reveals 440,000 fire alarms shipped in U.S., May 21, 2014, Reuters.
66. Nest reportedly shipping over 40,000 Learning Thermostats every month. January 30, 2013, The Verge.

XIAOMI

Xiaomi is a private Chinese electronics company founded in 2010. It was the world's fifth largest smartphone maker as of 2015. It has over 8000 employees, mostly in China, with some in Malaysia, Singapore, and it is expanding to India, Indonesia, the Philippines, and Brazil. Xiaomi was co-founded by eight partners, including Chinese venture capital funds, a Singaporean government-owned investment company, and the mobile processor developer Qualcomm. The company was estimated to have generated $20 billion in 2015.

Approach to IoT

Xiaomi's approach to home automation products is to make development for the platform relatively easy, so that developers can easily incorporate their products in the ecosystem, which boosts the growth of new products. Xiaomi also developed a unified "smart module" which is used as the control module for all the smart products in their product line. The module can communicate through Wi-Fi, Bluetooth LE, and Zigbee and can be embedded into appliances, wearables, and other small gadgets. Xiaomi's IoT platform is also tightly integrated with their cloud service, which provides external connection to other online services. Finally, a unified control app creates a coherent experience for users regardless of which platform is used.

Xiaomi's approach to the smart home platform:

1. Lower the entry requirement for smart home
2. Coherent experience based on the MIUI system
3. Create popular products
4. Increase communication and cooperation between products to increase usability

While Xiaomi's IoT products can be used with just a smartphone, the Xiaomi router allows off-site control and full automation even when the smartphone is offline. It serves as the hub for remote control when the user is not in home. The router also connects to the cloud to enable remote monitoring of the house when the user is away. Xiaomi has also developed TV set-top boxes and smart TVs that make use of the vast amount of videos online for entertainment.

In addition, the company also has several other notable IoT products, including a reverse osmosis water purifier, which provides real-time monitoring of the filter condition to the user's smartphone, and an air purifier that provides real-time air quality monitoring and remote control. The water and air purifiers specifically target China's pollution problem where large cities experience heavy smog. Xiaomi also has an IP camera for home monitoring and a rice cooker that allows remote control.

Xiaomi also helps other developers develop products that are compatible with their home control ecosystem. In addition, for users of the MIUI OS (operating system for Xiaomi's smart phone) the IoT control function is deeply integrated into the system allowing for more seamless control. MIUI OS is based on the open source Android OS but strips away all of the Google services that can't be accessed in China and it inherits the security features and improvements of new Android systems.

Technical Specifications

The Xiaomi router is an ARM based 802.11ac router (Cortex A9, 1.4 GHz, 512 Mb Rom, 256 Mb RAM, with some options for expandable storage). Based on the specifications, it is likely that the communication between gadgets and the router are Wi-Fi based since the smart module also supports Wi-Fi.

The air purifier is essentially a regular HEPA air filter that is "smart" enabled using the previously mentioned smart module, additional air quality and humidity sensors (using Japanese and Swiss made sensors). The smart module controls the filter's fan and connects to the smartphone and cloud where most of the "smart" features reside.

Relative Strength in the Marketplace

Xiaomi's main market is in China. While no official sales figures are available yet, the company's presentation slides at a Chinese IoT conference mentioned over 15 million online devices and 3 million daily active users of the smart home app.

Xiaomi has made an effort in expanding to overseas markets. While an estimated nearly 90 percent of Xiaomi's sales come from China, Taiwan and Hong Kong are two successful external markets for Xiaomi, where the products were met with overwhelming demand due to its consumer friendly prices. After overcoming some patent issues in India, Xiaomi has also expanded there and has become the country's third largest online smartphone vendor. It is estimated that 30 percent of all smartphone sales in India take place online. The company is focused on expanding in India, Indonesia, Brazil, and other countries.

Xiaomi's development in IoT creates a high level of synergy with its existing smartphone ecosystem. The current iteration of IoT at home is a one or two-system architecture:

1. Hub based: Where a central hub controls the peripheral devices, and a smartphone/computer tells the hub to do things.
2. Mesh based: Where everything talks to everything and is controlled by a smartphone.

As of 2015, Xiaomi had over 15 million online devices and over 3 million active daily users for their smart home app. With the smartphone serving as the center of the home IoT, Xiaomi can develop smart products that are easy to install and use without setting up additional control devices. For example, their smart scale and smart bulbs only require the user to pair with their smart phone. The simplicity makes it easier for new users to start in the Xiaomi ecosystem (with the caveat that without the Xiaomi router, some functionality might be limited).

Future Developments

One of Xiaomi's biggest strategic goals, in addition to expanding its market overseas, is to build up its smart things ecosystem. It has started with a smartphone and TV set-top box, followed by tablets. The smart router serves as the anchor and hub for Xiaomi's ecosystem expansion, as a central control for the smart bulb, air and water purifier, and other products. While the company has not disclosed any roadmaps, many speculate the company to continue its trend to make existing products "smart" and expand its reach into products that have seen some development in the West, including home security, home energy management, and entertainment systems. Home security would include products such as a smart-lock (Kwikset, Samsung) and energy management such as thermostat (Nest).

SMART THINGS

SAMSUNG SmartThings™

SmartThings originated as a Kickstarter project for a unified smart home hub in August 2012, raising $1.2 million and $3 million in seed funding from venture capitalists. After releasing the main product in August 2013 and securing an additional $12.5 million in series A funding, the company was acquired by Samsung for $200 million.

Approach to IoT

SmartThings' approach is to develop a product platform that serves as an intermediary between the various platforms and the end user. The company's core product is a hub and a free companion smartphone app to serve as a one-stop destination for users to control every gadget and appliance in the house.

Technical Specifications

The core product is a free SmartThings app on iOS and Android, and a SmartThings Hub. There are also several sensors such as window and door sensors, motion sensor, and an electric outlet.

The SmartThings Hub serves as the control center for the smart home. It connects wirelessly with compatible smart devices and gadgets to allow users to monitor

and control the home from anywhere with Internet connection. The hub is compatible with ZigBee (2.4GHz), Z-Wave (900MHz), IP, and Bluetooth, with a range of 50-130 feet. The hub uses an ARM Cortax-A9 1 GHz microprocessor with 512 Mb DDR3 ram, 4 GB flash. All SmartThings branded sensors use the ZigBee protocol.

Both Z-Wave and ZigBee protocols have a certain level of security built in. Z-Wave uses proprietary chip design to prevent hacking. ZigBee builds its security architecture based on the IEEE 802.15.4 standard, using 128-bit keys. In addition to the communication protocol, the SmartThings platform is also closely monitored and constantly improved to protect data security. Regular penetration tests are performed, and apps that access the SmartThings platform must follow strict security rules, such as compliance with OAuth method for online login, and constant app review by the company.

Relative Strength in the Marketplace

The SmartThings hub is commercially available in the U.S., Canada, U.K. , and Ireland. A small number of hubs were sold to users in parts of Europe as part of the Kickstarter campaign, but not commercially.

SmartThings provides a valuable add-on value to the home automation space to consumers, a centralized control center with high potential for new features because of close cooperation with appliance makers like Samsung, third party services, and the thriving developer community. The SmartThings hub is compatible with a wide range of products from various industry leaders, including Belkin, Bose, Cree, D-Link, EcoNet Controls, Ecolink, GE, Honeywell, Jawbone, Kwikset, LIFX, Leviton, Logitech, NYCE, OSRAM, Philips, RCS, Sonos, Sylvania, Tyco, Yale, Zen, and Ecobee. This thriving partnership and developer community means

that the SmartThings hub can work with almost all aspects of the automated home, such as connected lighting, smart locks, temperature control, and entertainment systems.

Future Developments

According to an interview with SmartThings CEO Alex Hawkinson in November 2015, the company is still in its early stages of development. [67] In the interview, Alex mentioned that the company has built the most open platform for the smart home in the industry, in terms of the choice of devices and the flexibility of the platform, and they intend to keep it that way.[68] The flexibility and openness attracts hardware partners and software developers to the platform to maintain growth. One of the goals of the company is to bring the product to the most consumers around the world, and the Samsung acquisition should help expand the product worldwide. The increase should also help the product contribute to problems such as carbon footprint (energy efficiency). The synergy with Samsung and its vast developer network also mean that in the future more appliances could come "connected" or even have built in hubs by default, and it would impact users by making their lives better, bring peace of mind and more energy saving, and added security.

MAIN PLAYERS

There are many players competing within this space. We have highlighted a few technology and platform providers above. Companies working in this industry include:

67. SmartThings' roadmap for the connected home: CEO Alex Hawkinson, November 18, 2015, Bootcamp.

68. 2015 Global IoT Decision Maker Survey: Key Findings, September 2015, International Data Corporation (IDC).


HEWLETT PACKARD
Honeywell
icontrol NETWORKS
INSTEON
CISCO
Jasper
LEVITON
QUALCOMM
NETGEAR
MARVELL
LG Electronics
nest
oregan networks
PROTO HOMES
SAMSUNG ELECTRONICS
Netgem
SAMSUNG SmartThings
technicolor
THREAD GROUP
Whirlpool
wink
ZigBee Alliance
Z-WAVE ALLIANCE

APPLICATIONS:
SMART RETAIL

Smart Supermarket

Sensors monitor the quality of perishable items in real time, triggering discounts on items near the end of their life, and automating ordering from suppliers to ensure the store can replenish the inventory as needed

Customer can request assistance towards a specific product via their mobile / wearable device

Price tags can be updated in real time

Smart shopping carts will help customers navigate the store's aisles efficiently based on their digital shopping lists

Products are suggested based on known costumer preferences and activity

Costumer can access extra product information, reviews and comments via their mobile / wearable devices

RFID Tags track inventory across the supply chain

Smart Shelves detect inventory level

Scanning a product such as a garment allows costumers to find other colors or models available and even order the item online if not available in-store

Automated checkout allows for a hassle-free experience as products are automatically scanned and billed to customers as they leave the store

Costumers are identified as they enter the store and provided relevant information to tailor their shopping trip. Store attendants can be alerted of VIP presence and dispashed to them

Personalized coupons can be offered to customers as they enter the store based on their purchase history

Beacons allow retailers to track customers through the store, enabling tailored product suggestions for items available within that particular store

In-store signage can be tailored to each location and updated in real time based on several factors, including data collected from IoT devices, local events, and trends

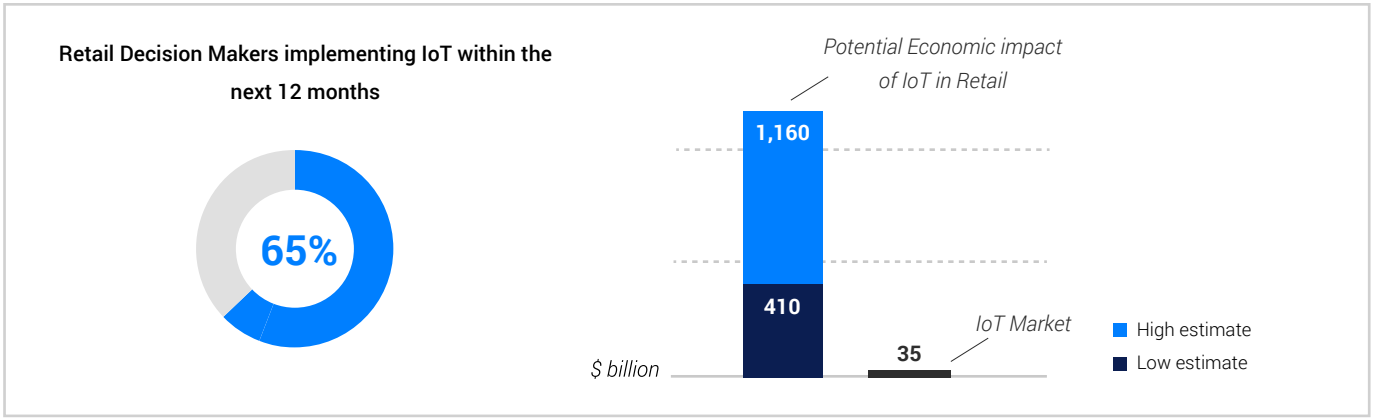
MARKET INFO

The IoT has been steadily increasing its presence within the retail environment, creating more efficient retailers and a better experience for shoppers. The smart retail store can cut costs by tracking inventory both on and off the shelves. Or better reach customers by knowing not only who but where they are, generating offers or providing information as they navigate through the store.

The retail sector has shown that it is ready to seize the opportunities that IoT can provide. A recent survey showed that retail was the industry sector where decision makers worldwide were most familiar with IoT; one of only 2 above 50 percent. [68]

The potential economic impact is significant. Estimates place it anywhere from $410 billion up to $1 trillion by 2025. [69] This would be gained from optimizing inventory, in-store offers to increase revenue from customers, and self-checkout or other automated assistance mechanisms, which reduce costs by reducing staff. A particular example would be reducing the cost of food waste, valued at $750 billion annually by connecting food packaging to supply chain systems and consumers or improving anti-counterfeit measures to minimize the estimated $1.7 trillion in damages.

While traditionally retail has been slower to adopt new technologies due to the fragmentation and limited margins in the industry, that does not seem to be the case with IoT. From the adoption of new payment to novel inventory control systems, the retail sector has been integrating some of the IoT's core concepts. Considering that throughout all industries, the majority of large companies (more than 1000 employees) are using or planning to use IoT technologies in the near future, it is safe to say that the retail industry is eager to capture that value.[70] A look at the IoT market for retail,



Left, Industry decision makers insight into IoT [68]. Right, Estimated potential impact of IoT applications by 2025 (Low estimate - dark blue, High Estimate - light blue)[69] and IoT market size by 2020.

68. 2015 Global IoT Decision Maker Survey: Key Findings, September 2015, International Data Corporation (IDC).

69. Unlocking the potential of the Internet of Things, June 2015, McKinsey & Company.

70. Global Business Technographics® Networks And Telecommunications Survey, February 2015, Forrester.

including hardware, software, and management services shows that it is expected to grow from $14 billion in 2015 to over $35 billion by 2020 (a CAGR of 20 percent).[71] This value is shy in comparison to even the most conservative economic impact estimate of $410 billion.

As in other sectors, the decrease in cost is perhaps one of the main enablers behind IoT adoption. Sensor prices have significantly decreased in the past decade. A clear example is that RFID tags now cost less than $0.1 and play an important role in adopting the IoT in the retail environment. These alone are expected to account for more than 15 percent of the IoT market by 2020.[71] We have also seen a decrease in costs in processing power, bandwidth and in access services, such as the cloud and analytics. Together they make the technology financially attractive to retailers looking to optimize their processes. Another factor that is changing the sector is the informed digital customer. This customer is used to interacting with real-time information. Retailers are looking for better ways to engage and fight for the attention of the modern shopper by providing them with what they seek.

WHAT IS THE SMART RETAIL SPACE?

The retail space is anyplace where a consumer buys items or services. While this has traditionally been limited to a physical space, that is no longer the case with retailers having both online and brick-and-mortar stores, which should interact with the customer and one another.

The smart retail space powered by the IoT aims to enhance the consumer experience and the retailer's efficiency.

A customer could enter a supermarket and be greeted with some of their favorite recipes. Upon deciding which one they would like to cook, the retailer's app could direct them toward the groceries required using an optimal path through the store. Smart packaging could provide not only nutritional info but also the age or quality of a perishable good. As they walks through the aisles, beacons detect their presence and they can receive personal alerts about particular items or sales and discounts. Because their shopping behavior is known, the offers and reminders are relevant and effective. Finally, they can exit the store through a contactless checkout system that requires no human interaction. This entire scenario is possible with technology available today and most people have experienced it parts of it, to some extent.

In another scenario, a consumer is looking to buy a new piece of clothing. Arriving at the store, the customer can receive an alert directing them to the item they searched for previously. Getting there by scanning the bar code quickly allows a smart device to retrieve information or check reviews on the item. They can check information on color, model, size or product availability and request it so that when they get to the

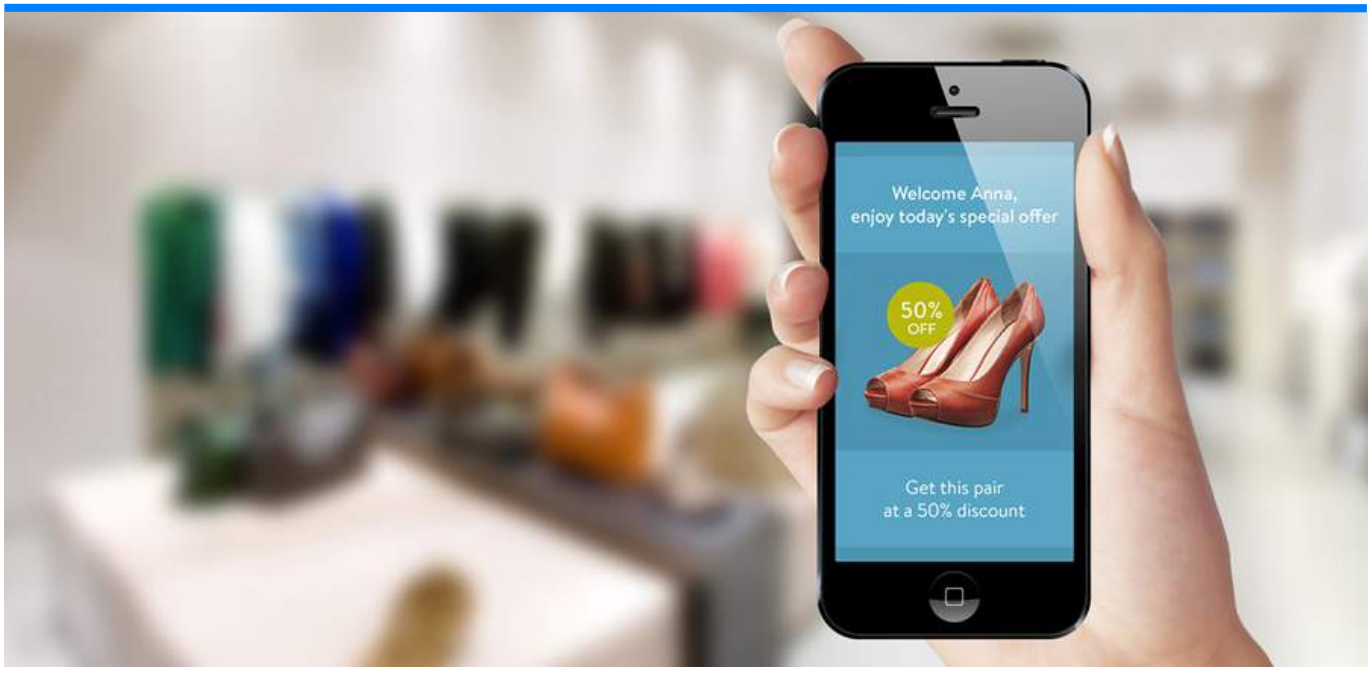
71. Analysis of the Global RFID Market in Retail, March 9, 2015, Frost & Sullivan.

fitting room the item is waiting for them. Smart mirrors can allow customers to try on virtual clothing and make suggestions for new items matching the customer's existing wardrobe. If the specific item the customer wants is not currently in stock, they can order it directly to receive it at home.

These scenarios describe ways to provide customers with a better shopping experience and illustrate new opportunities for retailers. Real-time personalized promotions take advantage of customer consuming habits to allow advertisement to be more efficient. Retailers can leverage this toward their own products or collaborate with advertisers to sell according to a consumers purchasing profile. The tracking of consumer preferences and habits can also lead to improvements in store layout, staff allocation, or efficiency, and eliminate inefficiency or waste.

The adoption of automated checkout systems can have a significant impact on retailers' costs. The ability of consumers to be charged as they select their items can reduce cashier staff requirements and reduce time spent waiting in line. Simultaneously, the widespread use of sensors in or on products could reduce losses from theft.

The IoT also provides the ability to know where your goods are at any point in the supply chain. Damaged goods can be traced back, in order to identify and correct the step at fault. Environmental conditions can be monitored throughout the process and its impact on product quality and longevity taken into account. Technology such as RFID tags and sensors embedded in individual products or packages can reduce product loss and increase inventory accuracy. Smart shelves can sense when they need to be restocked so sales aren't impacted while, at the same time, no time is wasted moving items that don't need restocking. Orders can be placed automatically and in real-time allowing for a more efficient supply chain and up to 10 percent



inventory reduction. Furthermore, monitoring consumption habits would optimize the store's stock to the population it serves and help predict unexpected surges in demand of specific products. Smart tags could respond to product shelf life, low turnout, or shelf space needs by being able to adjust the price in real-time.

The deployment of IoT in the retail space could improve shoppers' experience, help eliminate waste, lead to savings, and increased revenue for vendors willing to bet on it.

KEY TECHNOLOGIES

INTEL

Intel Corporation, incorporated in 1989, is engaged in the design and manufacture of digital technology platforms. Their focus on the Internet of Things is very clear, with the Internet of Things Group (IOTG) one of Intel's 5 business segments, which also includes the Client Computing Group (CCG), the Data Center Group (DCG), the Software and Services Group (SSG) and All Other.

How Intel is tackling the IoT challenge

Intel is one of the largest and highest valued semiconductor chip makers in the world. [72] Intel builds and supplies processors for customers like Apple, Samsung, HP, and Dell.[73] Intel also creates networking and computing devices, including motherboard chipsets, flash memory, graphics chips, and network interface controllers, and those devices are used by companies around the world.[73]

Intel has begun tackling the IoT challenge as it has recognized the strong potential in the marketplace.[73] Companies are looking for solutions that reduce operating cost and offers flexibility and efficiency in automation and integration of devices and Intel has helped companies achieve these goals.

Intel and its ecosystem are helping companies increase revenue, reduce operating cost, and increase efficiency.[74] Intel's IoT solution connects things and data and Intel uses its IoT solutions to solve industry specific challenges.[74] Intel's IoT solution is ready to solve problems faced by the retail sector. Intel's solutions like RealSense™ technology, dynamic digital signage, RFID and sensor technology, and Intel® Retail Client Manager help companies around the world to better serve their customers. [75]

72. Wikipedia, Intel Corporation.

73. The Healthcare Internet of Things Starts with Intel Inside, Intel.

74. Internet of Things Across Industries, Intel.

75. Internet of Things Case Studies, Snapshots, and Blueprints, Intel.

Technical specifications regarding Intel's IoT products and technology for retail

Intel has vast array of IoT devices and services that solve real world problems.

Digital signage is used for product advertisements, it delivers product information to a digital screen. Digital signage is widely deployed in various parts of the supermarket and it helps companies to increase sales and gain operational efficiency. Intel's digital signage is equipped with Intel® Atom™ processor E3815 and it is ideal for efficient imaging workflows and secure content delivery in digital signage. [76]

Intel digital signage is powered by the Intel Atom processor E3815 and it provides the following features:[77]

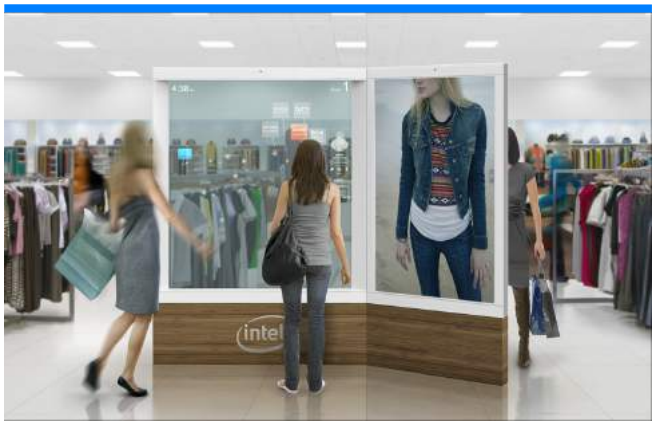
- HD simultaneous decoded streaming for at least two video stream
- Multi-video format playback
- Web application support
- Touch-screen interactivity

Also, manufacturers can choose from multiple operating systems including Linux, Windows, and Android 4.4 KitKat. The reference guideline also supports CMS solutions depending on which OS the manufacturer has chosen. Companies like iBASE and Advantech have used Intel processors to build their own digital signage.

Traditional vending machines cannot offer service touch screen functionality, gesture recognition etc., since most vending machines are equipped with low-end microcontrollers that offer less flexibility for the programmer for programming. Vending Machine operations include collecting money, providing change, and dispensing product.[78]

Intel® IoT Retail Gateway Reference Design provides necessary support for re-architecting traditional vending machines. [79] It turns the traditional vending machine into one that can offer great customer experience, easily supports new transactional models, and reduces operating costs. The main building blocks for this machine are the following:[80]

- Intel® IoT Gateway
- Vending machine I/O board
- Vending machine API



76. Intel® Atom™ Processor E3815 (512K Cache, 1.46 GHz), Intel.
77. Intel® Reference Design for Digital Signage (EL-10), Intel.
78. Intel® IoT Retail Gateway Reference Design for Intelligent Vending, Intel.
79. Intel® Reference Design for Intelligent Vending, Intel.
80. DSE 2012: Intel Features Large Interactive Kiosk.

Intel's hardware allows manufacturers to build kiosks with increased functionality. Examples include gesture technology, touch screen support, high definition audio and video streaming, gender determination, and height determination.[80] Intel powered vending kiosks can detect gesture and users can buy products without touching the machine.[81] Intel provides hardware solutions that enable manufacturers to build their own kiosk. For example, manufacturers can build digital kiosks with the help of Intel® NUC board. [82] Touch panel screens and Intel® HD Graphics add the support of user interactivity.

Intel's modern point of sale (POS) device offers many advantages to retailers and shoppers. It offers better transaction history, which helps retailers to sort inventories and helps them to make more effective promotions.[83] Intel offers many solutions for point of sale services, for example, motion computing turns mobile devices into a mobile point of sale device. [84] Intel's automated shelf compliance ensures product placement on store shelves fits the planogram model by using latest digital imaging technology. [85] This solution helps retailers to minimize inventory distortion.

Intel's mobile point of sale (mPOS) offers many advantages to shoppers and retailer. Retailers don't need to stand or sit in one place. They can individually serve customers which decreases checkout duration.

With the help of mPOS, retailers have more space for advertising and promotions. Intel mPOS devices offer many advantages to customers, as well. For example, if a customer is not sure about the size or color, retailers can easily swipe through the options to look for more information. If a particular product is not available, the mPOS device can provide the right direction with the click of a button or swipe. Intel's mPOS devices are equipped with latest Intel® processors and Intel Retail Client Manager provides more features like dynamic pricing, customer incentives, and transaction systems to mPOS devices.

NCR and Intel are making retail transactions more secure by using a combination of hardware authentication and end-to-end encryption.[86] This offers more protection that traditional transactional technology and it encrypts debit and credit card information as it passes through from the card reader

81. Intel powered vending kiosks @ IDF 2015.

82. Intel® NUC The Digital Kiosk Building Block, 2015, Intel.

83. Retail POS – Intel® Technology for the Point of Sale, Intel.

84. Mobile Checkout – Use Purpose-Built Devices to Avoid Issues, Intel.

86. Intel® Data Protection Technology for Transactions, Intel.

to the bank. For example, hackers like to inject malware in POS machines, which extract data and send it to different servers. If the data is already decrypted, it becomes easier for the hacker to steal valuable information. The hotel group Hilton Worldwide suffered a serious security breach when its POS machines were injected with potent malware.[87] The malware was able to extract information like debit and credit card details since it was decrypted to carry out transactions on terminals.

Intel® data protection technology ensures the security of transaction carried out using debit and credit cards by sending all the information through an encrypted connection. Intel® data protection technology provides security and it ensures data is safeguarded against malware. It simplifies endpoint authentication and retailers are relieved from security worries, as it offers an advanced level of data security. Retailers don't need to purchase any new hardware since Intel data protection technology for transactions is a software download and is compatible with many existing retail systems. It ensures secured remote server communication by using its built-in Intel® and McAfee® technologies.

Intel's intelligent software solution Intel® Retail Client Manager (Intel® RCM) enables retailers to deliver digital content to the screen with greater impact. Audience analytics increase the effectiveness of ad campaigns. It also enables retailers to remotely manage marketing campaigns.

Intel AIM Suite provides the retailers with statistical information, such as how shoppers are interacting to visual messages, how shoppers are moving through retail environment, among others. By using anonymous sensors and highly sophisticated computer algorithms, AIM suite can provide statistical information about shoppers. It can generate user profiles based on gender, age, and based on viewing time and duration. AIM suite reduces the labor cost of human-based retail audience research since it can provide accurate statistical information without human intervention.

Specific information on whether Intel is offering a hardware solution, software solution or combination of both

Intel's retail solutions include both hardware and software solutions. In addition to Intel's retail solutions, a powerful combination of Intel's hardware and software has enabled many companies to come up with their own retail solutions. For example, Provision's next-generation 3D kiosks are built using Intel's hardware and software. [88]

Company Case Studies

Intel IoT solutions have been successfully implemented by many industries. Below we have provided a summary of successful deployment of IoT solutions.

87. Hilton Hotels admits point-of-sale malware hack, November 25, 2015, Computing.

88. Tomorrow's Digital Signage, Today With 3D Holographic Kiosks, 2016, Intel.

CKE Restaurants Holdings

CKE Restaurants Holdings, Inc. is the parent company of Hardee's, Carl's Jr., Green Burrito, and Red Burrito. The company headquarters is located in Carpinteria, California. Like many traditional companies, Hardee's customers used to place orders at the counter or in the drive-thru. But the restaurant was interested in improving customer experience and began exploring using kiosks to improve the customer experience. With the help of kiosks, the company could improve customer satisfaction and improve the efficiency of operations. The company figured out that they could also improve add-on sales. However, at that time, kiosks were too expensive to implement in restaurants.

In short, the company had the following goals:[89]

- **Enhance the customer experience** – Provide an engaging, interactive experience as customers select food and beverages, and enable customers to speed up the ordering process.
- **Boost sales** – Make the most of upsell opportunities and serve more customers per day.
- **Accommodate changing customer preferences** – Cater to customers who increasingly prefer using technology for retail and restaurant transactions.
- **Control costs** – Deploy robust, reliable kiosks that can provide a responsive, interactive experience without the costs of using proprietary systems.

Hardee's deployed kiosks in their restaurants. The kiosk is based on the Dell OptiPlex 3030 All-in-One PC, is equipped with Intel's core i5 processor, and driven by a Windows 8.1 Operating System. Customers can use the 24-inch screen of the kiosk to make their menu selections.

The outcome of this was impressive. Since customers used the kiosk to order food, it helped them avoid standing in line. Moreover, fewer errors are made during food orders. The visually appealing screen attracts customers of all ages and they enjoy customizing their own food. The speed of food delivery also increased. The company expects that the sales of the restaurant will gradually increase after the installment of the kiosk. The kiosk offers flexibility as it allows employers and managers to run additional enterprise applications and helps the company reduce IT costs since they can use a single PC for multiple functions.

Dunkin' Donuts

Dunkin' Donuts is one of the largest coffee and baked good chains in the world, founded by William Rosenberg in 1950. The company sells doughnuts, bagels, baked goods, and beverages. It serves millions of customers around the world.[90] In order to further improve its customer experience and operational efficiency, Dunkin' Donuts has decided to replace its static menu board with dynamic digital signage solutions from NCR. A static menu board requires time to prepare. Since the menu selection varies from location to location, a static menu board needs to be created based on where it is located and what the restaurant offers. The static menu board also needs to be transported to the restaurant.

89. Case Study. Delivering a Satisfying Customer Experience with Kiosks Based on Intel® CoreTM Processors, 2016, Intel.

90. Compelling Digital Signage for Retail, 2014, Intel.

In short, the company wanted to meet the following goals:[91]

- **Engage the customer** – Help drive sales and influence guest purchasing decisions by using compelling, high-definition media to call attention to particular products, display important product information, and present limited-time offers without cluttering restaurants with printed signs.
- **Streamline processes** – Reduce the time, costs, and complexity of updating static menu boards.
- **Accommodate variety, increase consistency** – Provide menu content tailored to the offerings available in each restaurant while ensuring that products common to all restaurants are displayed consistently from one to the next.

The company decided to use NCR Vitalcast digital signage solution which includes digital screen and media player, equipped with an Intel® DQ77KB motherboard, Intel processor, and Intel SSD.

The NCR solution improves operational efficiency, because the digital content can be pushed to store media players from a centralized location. Task like pricing changes have been made easy since the POS system can be integrated with the digital system and new price information is immediately available to the digital menu board. The task of promoting of new products has become easier. The media player improves customer experience as new product information, limited time offers, and information about products can be presented without using printed signs. The company is looking forward to expanding its use and using Intel® vPro™ technology which enable remote system management.

Relative strength in the Marketplace

Intel is constantly doing research on new IoT solutions that can generate revenue, increase operational efficiencies, increase productivity, and improve customer experience. The Intel responsive store is one of the new technologies that will target the retail industry and it is expected to generate a more engaging shopping experience. This new technological innovation will help shoppers find products and update the customers about new products. The solution can also offer expert suggestions to customers.

Many companies around the world have used Intel's innovative IoT solutions and Intel is gradually securing its place in the IoT market place. Intel introduces IoT solutions that mainly target retail industries. Bridget Karlin, the managing director of the IoT Strategy and Technology Office at Intel's Internet of Things Group, mentioned how good a fit the Retail industry was towards Intel IoT technologies.[91] Karlin also mentioned that around 50 billion devices will come to the market by 2020. IoT solutions have enabled Intel to generate revenue and it is reported that Intel generated $2.3 billion by selling its IoT solutions. This market should continue to grow for Intel.

90. Compelling Digital Signage for Retail, 2014, Intel.
91. Retail Industry a Good Fit for Intel's Internet of Things, February 3, 2016, The Street.

SMARTRAC

SMARTRAC

With operations and production facilities in numerous countries, SMARTRAC is the world's leading developer, manufacturer, and supplier of products using radio-frequency identification (RFID) technology. It has sales offices and production facilities in the Americas, Asia, and Europe. Private equity firm One Equity Partners acquired nearly 90% of SMARTRAC in 2010.

Approach to IoT:

RFID uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Unlike bar codes, the tag doesn't need to be in the line of sight of the reader, so it can be embedded in the tracked object. RFID tags are used in many industries. For example, a RFID tag attached to an automobile during production can be used to track its progress through the assembly line; RFID-tagged pharmaceuticals can be tracked through warehouses; and implanting RFID microchips in livestock and pets can provide positive identification of animals.

Using RFID technology, SMARTRAC makes products smarter and enables businesses to identify, authenticate, track, and complement product offerings. SMARTRAC offers a digital signature that can be linked to objects, including industrial assets, consumer goods, credit cards, passports, access products, vehicles, and more.

In 2014, SMARTRAC entered the IoT. SMARTRAC has realized that there is significant value in connecting the unconnected three trillion products sold annually. Leveraging its global research and development,t production, and sales network, SMARTRAC now combines physical products with digital and web-based services using its IoT platform SMART COSMOS, empowering the ecosystem of connected things. Global opportunities that SMARTRAC is looking to address with COSMOS:

- Connecting brand products could help to reduce counterfeiting and piracy damages, which will amount to $1.7 trillion annually by 2015.
- Linking food packaging to supply chain systems and consumers' mobile devices can help to reduce the current food waste, valued at $750 billion annually.
- Exposing product-attached data to a community of 430,000 mobile app developers and 2.2 million apps is going to lead to a new era of innovation and value creation.
- In order to "connect simple things," there is a need for a universal "toolbox" that can be used by a broad array of players in the ecosystem to link

RFID tagged items to the digital world in a way that is simple, fast, and cost-efficient.

SMART COSMOS offers a portfolio of tightly integrated, cloud-based services that enable system integrators, IT departments, and software engineers to rapidly innovate new solutions that connect physical objects to the digital world by linking cloud-based tag credentials to the description of belongings or company assets. [93]

Technical specifications

Smartrac's Smart Cosmos is offered as part of a three-part system, is fully integratable, and is based on the each of their clients business needs.

Profiles

One of SMARTRAC's SMART COSMOS offerings is a cloud-based solution called Profiles, which is intended to enable supply chain monitoring for a monthly fee. Profiles provides subscribers with full visibility into supply-chain and manufacturing metadata associated with RFID transponder procurements. A web front-end provides ad-hoc query and reporting capabilities, while a set of web services provides software engineers with access to supply-chain metadata in an automated fashion.

Profiles offers unrestricted access to timely and trustworthy RFID supply-chain data that can help management reduce costs while simultaneously improving operational efficiencies.

Major Product Features: [94]

- Full featured Web UI that supports ad-hoc reporting
- Easy intellectual property and license risk-management capabilities
- Comprehensive set of manufacturing metadata available
- Extensive documentation and support for third-party developers
- Robust set of manufacturing metadata available

Objects

Objects is a versatile repository that allows businesses to capture, organize, and act upon all types of data from always-on sensors, smart devices, and existing back-office systems. Data is delivered using simple REST Web service calls that are compatible with all modern software development environments. The platform can manage object data ranging from relationships to repetitive interactions, from technical specifications to multimedia files. It's possible to integrate with Profiles for authenticity capabilities, and with Flows for making business rule decisions using Objects data.

Manufacturing processes, always-on sensors, customer engagements, and even social media platforms yield data that companies want to strategically leverage to drive new revenues. Rapidly capturing of data in a usable manner requires a large IT

93. Empowering the Ecosystem of Connected Things, SMARTRAC.

94. Profiles powered by SMARTCOSMOS, 2014, SMARTRAC.

infrastructure project that allows easy access to analytical engines.

Major Product Features:[95]

- Easily define a product, customer, or vehicle as an "object"
- Ability to capture "yes" or "no" relationship status between arbitrary objects
- Ability to capture recurring interactions between arbitrary objects
- Accurately represent either a path traveled or a 3D structure with native GeoJSON specification support
- Type-safe key-value (metadata) support
- Robust multimedia support
- Object hash-tagging
- Accurately track relationships, interactions, and arbitrary events using timelines
- Full system audit, including both write and read operations
- Manage hardware and device definitions
- Explicit multi-tenant architecture
- Centralized user management architecture
- Easy integration with back-office systems via JSON events pushed over HTTP
- Automatic digital signature generation upon file upload to prove file hasn't been tampered with while stored in the cloud
- Highly scalable Cloud PaaS (Platform as a Service) architecture capable of handling billions of objects

Flows

Flows helps software engineers speed the implementation of fully automated RFID-centric, sensor-driven workflows while lowering deployment costs. Software engineers use Flows to visually construct business rules that link together people, sensors, passive objects, and business processes with back-office systems. When Flows is deployed alongside other SMART COSMOS platform services, including Profiles for supply chain visibility and Objects for capturing any type of personal characteristics or product definitions, businesses can harness new types of previously inaccessible micro-interaction.

Businesses are actively looking for ways to harness new types of micro-interactions between people, sensors, and passive objects in order to achieve higher levels of productivity while simultaneously lowering operating costs.

Major Product Features: [96]

- Rich business rule definition capabilities including native support for forks, joins, loops, and actions
- Ability to integrate with sensor or back-office system via native REST Web services, TCP Sockets and UDP broadcasts
- Ability to identify one or more triggering events in an external system or database that cause a specific business rule definition to execute as a result of the change in state
- Composition of business rules is natively supported

95. Objects powered by SMARTCOSMOS, 2014, SMARTRAC.

96. Flows powered by SMARTCOSMOS, 2014, SMARTRAC.

- Full support of both synchronous and asynchronous actions within a business rule
- Complete support for accessing and working with data from multiple databases within a singular business rule (Oracle, MySQL, or Microsoft SQL Server)
- Integrated communication capabilities via email and SMS
- Templates used to dynamically generate message content based on the data accessible to the overall rule being executed
- Business rule execution intrinsically captures where, who, how, and when
- Multi-platform business rule designer
- Native Profiles integration support
- Native Objects integration support
- REST endpoints for managing and executing business rules
- Openly published XML Schema for business rule definition to allow developers to craft rules without requiring a user interface

Specific information on whether SMARTRAC IoT is offering a hardware solution, software solution, or combination of both

In order to support its customers, system integrators, and business partners, SMARTRAC is complementing its hardware related heritage with the provisioning of digital information stored in its tags. This information is made available to customers through cloud services and applications, enabling the customers to provide enriched product features and networking related benefits. Therefore, COSMOS is designed to be a cloud-based software solution.

Company Case Studies

Among the potential applications of COSMOS, below are some ways stakeholders can benefit:

- System integrators and software developers can easily create new applications for authentication, identification, and tracking of goods.
- Marketers can create unique and truly personalized customer experiences by better connecting offline brand items to the online world of consumers along the customer journey from promotion to repurchasing and along the product journey from production to recycling.
- For big data opportunities, SMART COSMOS has the largest ID repository with more than 1.7 billion new object IDs per year. It is also open to other RFID companies and market partners after a security certification procedure.
- SMART COSMOS also supports the verification of intellectual property (IP) rights to minimize the financial impact risk from third party rights holders while at the same time supporting the enforcement of SMARTRAC's IP rights.
- SMART COSMOS platform services take care of the complex work necessary to build RFID-centric powered solutions in any market, allowing system integrators, IT departments and software developers to focus their time innovating in their specific vertical market. Rather than purchasing and integrating software, it's possible to use SMART COSMOS to build a system specific to a company's unique needs.

Relative strength in the Marketplace

SMARTRAC is the world's leading developer, manufacturer, and supplier of RFID products and services, providing both ready-made and customized products and services suitable for a large number of applications. SMARTRAC has attracted Keen IO, MachineShop, Sasken, Senitron, and Stormpath as initial Smart Cosmos Partners.[97] Recently, ThingBlu has selected Smartrac's IoT platform Smart Cosmos for legal cannabis industry solutions.[98] RR Donnelley and Smartrac have teamed up to jointly market an innovative process for RAIN RFID implementation that will enable growth in the number of products connected to the IoT through smart packaging and related solutions. [99]

The focus on keeping their platform open to other RFID companies and any market partners has been linked to Smartrac's success, something that is acknowledged by Christian Uhl, the company CEO recently: "We are extremely proud that, by developing extensions for Smart Cosmos, such well-known market players are explicitly demonstrating their trust in our IoT platform and its monetization potential. (...) We warmly welcome collaborators to Smart Cosmos, and look forward to welcoming more partners soon, as Smart Cosmos is designed to be an open platform for everyone who wants to reap the benefits the IoT has to offer." [100]

ESTIMOTE AND IOT

estimote

Estimote, Inc. is a technology start-up building a sensor-based analytics and engagement platform. Headquartered in New York, New York, Estimote has been developing beacon technologies since 2012. The company is currently piloting solutions with the largest retailers in the United States and Europe and it is also shipping Developer Kits daily, which consist of sample beacon devices, as well as SDK, which enables mobile developers and retail consulting agencies to add micro-location context to their mobile apps.

Approach to IoT:

Estimote is building a sensor based context and micro location platform for mobile developers. They have a team supporting more than 75,000 developers working with Estimote products. Estimote has $13.8 million in funding from the following 14 investors as of February 2016: Bessemer venture partners, Betaworks, Birchmere Ventures, BoxGroup, Commerce Ventures, Digital Garage, FundersClub, HomeBrew, Innovation Endeavors, Javelin Venture Partners, Josh McFarland, New Europe Ventures, LLC, Valiant Capital Partners, and Y Combinator.[101]

97. IoT Solutions powered by SMART COSMOS: Creating Unmatched Value for Your Business, SMARTRAC.

98. ThingBlu selects Smartrac's IoT platform Smart Cosmos for legal cannabis industry solutions, March 23, 2016, IoTNOW.

99. RR Donnelley and Smartrac Jointly Market Innovative RFID-Based Smart Packaging and Labeling Solutions, RR Donnelly.

100. SMARTRAC to Enhance Smart Cosmos IoT Monetization Ecosystem, October 6, 2015, SMARTRAC.

101. Estimote, Crunchbase.

Technical specifications

Estimote offers beacons of different sizes, forms, and capabilities depending on the desired application. The two main types are the beacons and the stickers. The company also offers a location software solution to monitor, track, and program the beacons deployed.

Estimote Beacon

Regular beacons provide location context for venues having been designed for static locations. These can have a range from 70 to 200 meters.

- 32-bit ARM® Cortex M0 CPU
- Accelerometer
- Temperature sensor, motion, ambient light, magnetometer, pressure
- 2.4 GHz radio using Bluetooth 4.0 Smart, also known as BLE or Bluetooth low energy.
- Can last more than 3 years, when on default settings, on a single CR2477 battery.

Estimote Stickers (Nearables)

Estimote Stickers are much smaller beacons. Stickers do the same beacons do for physical objects. Stickers can be attached into a "nearable," a smart object broadcasting data about its location, motion, and environment to a mobile device in range. Stickers make individual objects "smart." Stickers broadcast data packets using two protocols: iBeacon (infrequently) and Nearable (frequently). This allows it to include more data in the packet itself and still benefit from iBeacon features.[103]

- 3 mm thin
- 32-bit ARM® Cortex M0 CPU
- Accelerometer
- Temperature and motion sensor
- 2.4 GHz radio using Bluetooth 4.0 Smart, also known as BLE or Bluetooth low energy.
- Stickers broadcast Estimote's Nearable protocol
- Depending on usage, the battery can work for even a year
- Stickers are waterproof, however, extreme weather conditions can affect performance. [104]
- Stickers are adhesive on one side, and there's a small PCB inside and it can broadcast a Bluetooth Smart signal up to about 7 meters (20 feet).

103. Beacons, What are nearables? What is Nearable protocol?, Estimote.

104. Beacons, Can Estimote Beacons be placed outdoors?, Estimote.

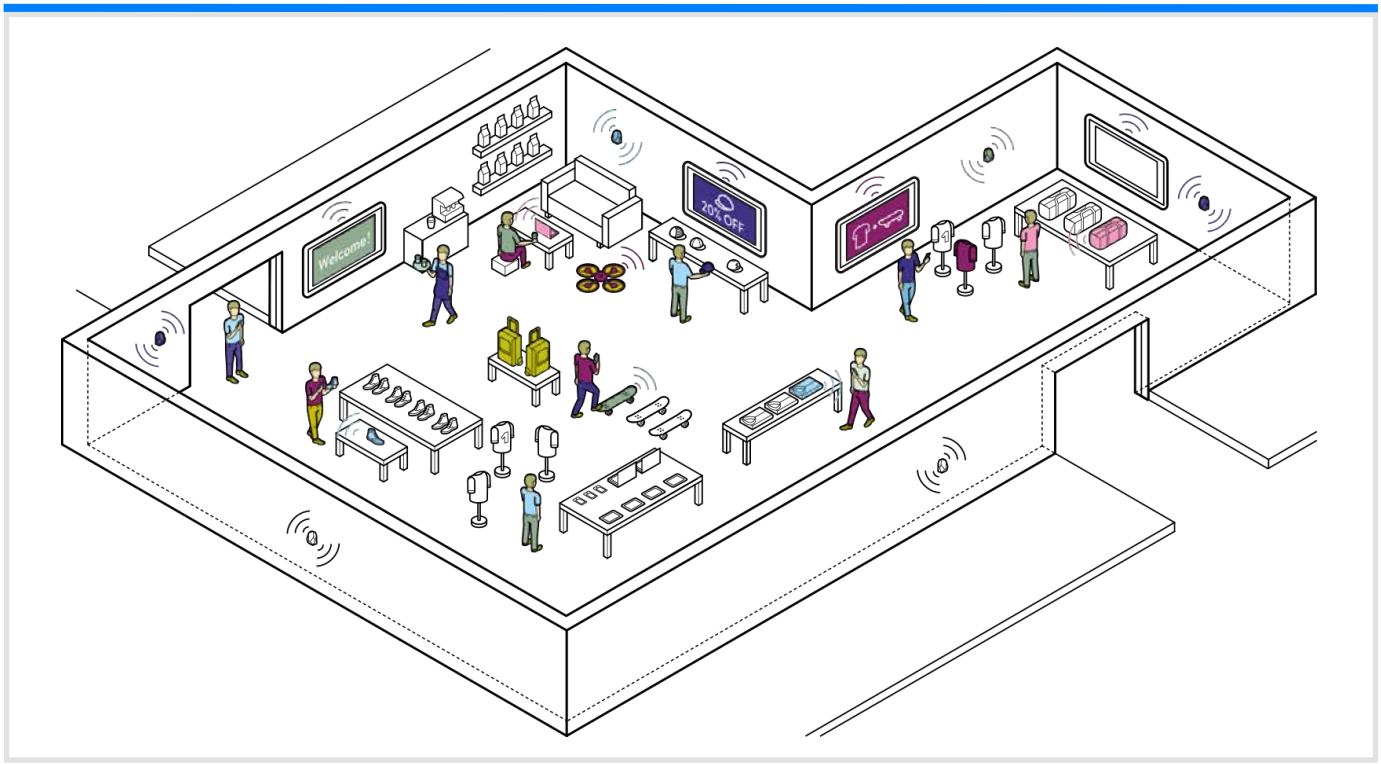
Estimote Indoor Location

Estimote Indoor Location is software for mapping indoor environments that can be used for identifying the location of people and objects down to few meters. With Indoor Location app and SDK, developers can easily set up interactive locations and incorporate them into apps.[105] Indoor Location is based on beacons and advanced data science for establishing the position of users and objects.[106] Precision depends on location shape and size. It can be used in retail, to help a customer navigate through the store or find things on shelves. In hospitals, it could be used to guide doctors, patients and visitors. In airports, to show travelers to their gates — the possibilities are endless!

Company Case Studies

Estimote provides a list of over 100 apps and projects using Estimote Beacons in categories including: [107]

- Art/museum
- Education
- Events
- Everyday life
- Hospitality and small business
- Retail
- Social
- Workplace and industry



105. Indoor location, What's Estimote Indoor Location?, Estimote.

106. Estimote, Proxbook

107. Get Inspired, Apps and Projects with Estimote, Estimote.

Below are descriptions of three examples from the retail category.

Qpony uses beacons to deliver 30,000 deals and go viral

The Qpony app is used to receive and redeem deals from brands like IKEA, Starbucks, and H&M.[108] It's the biggest coupon app in Poland. The results of Qpony's deployment of its first iBeacon campaign at Factory Poznań, a major clothing retailer, include: [109]

> *"Fashion brands located at Factory prepared 67 deals that were delivered as coupons through the Qpony app. The promotion lasted for the first two weeks of April: nearly 30,000 offers reached 10,181 users of Qpony who visited Factory during this time. In order to enhance shopping experience they offered special high value coupons distributed through Estimote Beacons. Over 90 percent of those extra coupons were redeemed. Virality also played an important role: after redeeming coupons, 78 percent people used the option to share the deal with a friend, by sending them a unique link…. In fact, they're so satisfied, that they're already working on expanding iBeacon-based deals to other Polish cities, including Warsaw, Kraków, and Tricity."* [110]

How Adored uses BLE beacons to increase brand loyalty

Adored is building a unified loyalty experience platform that's simple to use for both customers and business owners. In the U.S., the app is quickly gaining traction. There are already many resorts, restaurants, and coffee shops on board all across New England, and the app has thousands of users. Estimote beacons are deployed for any Adored location. You walk into a bar or a restaurant, and the Adored app saves the information about your visit thanks to a beacon nearby. When it tracks enough visits, you earn a reward, such as a free coffee or a special offer for the meal of the day. The Adored platform then automatically tailors the experience to different users based on beacon visit behavior, maximizing engagement and conversion. Outcomes for businesses include an up to 20 percent increase in weekly visits after joining the Adored platform and a 5-10 percent conversion on real-time upsells. [111]

Notify Nearby converts 52 percent of users into potential buyers with Estimote

The Notify Nearby app receives location-based notifications just about anything, from new product lines to special offers in the vicinity. "The beta release of Notify Nearby was tested with a select group of shoppers and stores across Manhattan and suburban New York City. 52 percent of testers passing by a store decided to enter after receiving a notification from Notify Nearby triggered by beacons.And 28 percent of people entering the store made a purchase. Additionally, the engagement rate for notifications was 67 percent: a six fold increase over average push notifications." [112]

---

108. Qpony.
109. Factory.
110. Get Inspired, Qpony uses beacons to deliver 30,000 deals and go viral, Estimote.
111. How Adored uses BLE beacons to increase brand loyalty, October 12, 2015, Proxbook.
112. Get Inspired, Notify Nearby converts 52 percent of users into potential buyers with Estimote, Estimote.

Relative Strength in the Marketplace

Forbes presented a primer on beacon technology in 2015, in a piece titled "Beacon Technology: The Where, What, Who, How and Why."[113] It notes that, "Beacons have been generating buzz since 2013, when Apple first introduced iBeacon technology. And while it may have appeared for a time that this new way of connecting with customers might be slow to catch on, today it's catching fire.[114] In early 2015, BI Intelligence reported that beacons would be driving $44 billion in retail sales by 2016, up from $4 billion in 2015.[115] Then in July of 2015 came the big news that Apple and IBM teamed up on a host of new apps to incorporate analytics and iBeacons.[116] And, in August of 2015, Ad Age reported on the impending reinvention of retail by digital technology, as the physical and digital worlds converge in stores.[117] Estimote's is in a prime position to capture this market, is well established with clients, including some of the major players and trendsetters in this field such as Google, Target, or Disney. [118]

SAP

SAP is the world leader in enterprise applications in terms of software and software-related service revenue. Based on market capitalization, SAP is the world's third largest independent software manufacturer. With over 80K employees in 130 countries, it is a global company that has been actively working on IoT since at least 2014.

Approach to IoT:

SAP tackles the IoT challenge by offering a wide range of software designed to meet the diverse needs of its many retail clients. For example, SAP helps their retail clients tackle problems, like inventory management, customer experience, timing of promotions, financial issues, and human resources concerns.

Most importantly, SAP provides cloud data storage and analytics, which help their clients make better business decisions in real-time. Among other benefits of SAP for retail, the data generated and analyzed helps clients run

113. Beacon Technology: The Where, What, Who, How and Why, September 1, 2015, Forbes.
114. Why Apple's iBeacon Hasn't Taken Off—Yet, August 28, 2014, Bloomberg.
115. How beacons — small, low-cost gadgets — will influence billions in US retail sales, February 9, 2015, Business Insider.
116. Apple and IBM release 10 new apps, incorporating analytics and iBeacons, July 21, 2015, PC World.
117. Retail Is About to Be Reinvented, Driven by Digital Technologies, August 28, 2016, Advertising Age.
118. List of the Nine Biggest Beacon Manufacturers, March 4, 2014, Nodes.

targeted promotions, avoid over-stocking or under-stocking their products, while minimizing fraud in the supply chain. This, in turn, leads to increases in revenue and profitability for their clients.

Technical specifications

The center of SAP's ability to provide real-time data storage and analysis is its in-memory computing database management platform, the SAP HANA Cloud Platform. Because SAP HANA stores all data in the cloud, data can be accessed at anytime, from anywhere, allowing clients to draw real-time insight from past and ongoing transactions. SAP offers three different HANA business suites, SAP S/4HANA, SAP HANA Vora, and SAP BW/HANA. These can be deployed "on-premise" or through the cloud, either way SAP HANA offers advanced in-memory processing and integrated data-management. The SAP HANA suites provide database services, analytics processing, app development, data access, administration, and security.

SAP's software solutions

SAP offers an extensive array of software and platforms for retail companies that provide solutions to a variety of problems that retail companies face. SAP solutions for retail include supply chain management, product life-cycle management, financial management, and event management. SAP business software packages, such as SAP for Retail, SAP Point-of-Sale, SAP Business Warehouse, SAP Extended Warehouse Management, and SAP Supply Chain Management. SAP licenses out some of their software with a perpetual license and others through a monthly licensing subscription. SAP does not offer hardware solutions but partners with several companies to provide hardware. SAP HANA can only be installed and configured by certified hardware partners. These partners include HP, Fujitsu, IBM, Cisco, Hitachi, Dell, and NEC.

Company Case Studies

SAP has customers in many different industries, including automotive, banking, healthcare, sports and entertainment, and retail. Within the realm of retail, many companies have reported great success using SAP software and platforms, below are a few case studies of such implementations.

Migros is the largest retailer in Switzerland and is one of the 40 largest retailers in the world. Upon implementation of SAP NetWeaver Business Warehouse application on the SAP HANA platform, some Migros' report generation times were cut from 22 minutes to 17 seconds and data was compressed from 550 GBs to 60 GBs. Because reports were so readily generated, planning was linked to real-time market demand, allowing Migros to avoid unnecessary purchases and increase profitability.

Using SAP Business Warehouse, SAP Customer Activity Repository, SAP ERP, SAP for Retail, SAP Mobile Platform, SAP Point-of-Sale (SAP POS), SAP Service and Support, SAP SuccessFactors, ULTA was able to manage real-time inventory, provide personalized recommendations to customers and, in turn, increase customer loyalty.

Using SAP Apparel and Footwear, Life is Good Inc. was able to ensure their products were delivered on time, something they struggled with before turning to SAP for retail solutions.

Similarly, Harry & David used SAP ActiveEmbedded, SAP Active Global Support, SAP Extended Warehouse Management (SAP EWM) to automate and streamline warehouse operations.

The outdoor retailer REI used SAP ERP, SAP Planning for Retail to create a single platform integrated merchandising tool, providing REI with better operational planning.

Relative strength in the Marketplace

SAP has created strong industry partnerships with major IoT players, such as Intel, Bosch, and Siemens. These partnerships give SAP the strength to move forward as a leader in machine-to-machine communication and IoT database management industry.

SAP has a strong foothold in the IoT industry with the launch of its SAP HANA Cloud Platform. SAP has the intention to migrate all of their services to the SAP HANA Cloud Platform. This platform has and will continue to increase SAP's IoT market share. The SAP HANA Cloud Platform promises to revolutionize database services, accelerate analytics, optimize data access and integration, create and manage innovative applications, and decrease time and effort of IT administration.

In terms of where SAP is going in the retail realm, they have hopes of making the "store of the future" a reality. Among other plans, they would like to harness the power of RFID by tagging products, which would pull up product information and reviews on customers' smart-phones or be "scanned" for purchase as it is put into a shopping cart for a better customer experience. On the merchant end, they hope to provide in-store analytics and beacon technology to drive customer satisfaction and increase sales.

IBM

International Business Machines Corporation (commonly referred to as IBM) is an American multinational technology company headquartered in New York, United States, with operations in over 170 countries. Its focus on the Internet of things is well complemented by its Watson offering, and the company is poised to play a prominent role with the evolution of IoT.

Approach to IoT:

The task of extracting useful information from immense data sources is not always possible and it can easily exceed the computing capability of normal machines. IBM Watson can help us to process unstructured data and garner useful information by using its machine learning and natural language capability.[119] It can reveal insight from large amounts of unstructured data.

IBM Watson is helping companies to flourish by combining IoT data with other data sets to learn and then apply its knowledge to help the company make better predictions and profit from those.[120] IBM Watson's cognitive computing technology can make IoT systems smarter by making IoT devices learn, adapt, and communicate information with other IoT devices, enhancing the capability of the whole IoT network.[121] Cognitive and edge computing can help

119. Go beyond artificial intelligence with Watson, IBM.

120. The Internet of Things becomes the Internet that thinks, 2016, IBM.

121. The Cognitive Era, IBM.

organizations extract and understand the meaning of IoT data. Cognitive technologies help companies to understand unstructured data so that companies can optimize their business operations and learn more about their customers. IBM Watson's platform cognitive IoT can help companies achieve this goal by connecting devices quickly, infusing intelligence into applications and analyzing IoT data to gain more visibility into business processes.

The IoT is vast, complex, and it is changing continuously. Moreover, it generates huge amounts of data, from sensors,, audio, video, and more, which makes it difficult for traditional computing systems to store and retrieve valuable information. IBM Watson addresses these issues. It can extract and analyze IoT data, including structured and unstructured data, to uncover patterns and gain better understating of the business process to make better recommendation.

Technical specifications

IBM Watson offers a wide range of software, which retailers can use to carry out their day-to-day business operations in an efficient manner. Below are some of the IBM software solutions that can help retail business owners conduct business operations more quickly by handling complex business predictions and decisions.

IBM Watson Analytics

In a real-life scenario, it may take weeks to take complex business decisions, since there is the need to search through gigabytes of data to make accurate predictions. IBM Watson Analytics, an intelligent data discovery tool that mainly operates in the cloud, was developed to analyze and uncover hidden patterns.[122] It automates the process of data visualization and data prediction by providing answers quickly. The software offers many advantages, such as the ability for users to upload data or analyze information and get a graphical representation of uploaded data. Users can easily create dashboards and infographics. With the help of IBM Watson Analytics, it's possible to retrieve Twitter data posted by customers for further analysis. Users can also share graphs and other information with each other. With the help of IBM Watson Analytics for Social Media, valuables statistics about customers from Facebook and social media sites can be integrated into the analysis. All this information, including social media statistics, can help retailers to make more accurate business decisions since they will be able to understand customers behaviors and customer interactions with different products. IBM Analytics offers cognitive capability, automatic data discovery, and predictive analytics that can help organizations to make critical business decisions quickly and increase profits.

Users do not need any specific hardware to run IBM analytics. Any mobile device or workstation that works with supported browsers can run the software.

122. IBM Watson Analytics, IBM.

IBM Watson Analytics for Social Media

IBM Watson Analytics for Social Media can help retailers to retrieve valuable information from different social media sites such as Facebook and can analyze that information to get more visibility into customer interaction.[123] Data can be segmented into different groups based on gender, geography, or other characteristics. The solution can help identify hidden patterns and trends to make better business decisions. The software offers many advantages to users without requiring any formal training to use it. Simply inputting a topic into the system will show all the relevant statistics in a user friendly, intuitive, graphical manner. The system also helps to eliminate any guesswork by suggesting a starting point for the analysis. The software comes with many features, like automated sentiment analysis to help understand customers sentiment on any particular topic. The software has a rich analytical capability and can easily compare data from different sources, for example, it's possible to compare customer sentiment with actual sales after the launch of a new product.

IBM Watson™ Personality Insight

IBM Watson™ Personality Insight enables the businesses to better understand their customers.[124] The service provides an Application Programming Interface that can be used to derive meaningful information from social media, enterprise data, and other digital communications. It uses linguistic analytics to infer personal characteristics, like the Big Five, Needs and Values about customers.[125] IBM Watson Personality Insight can provide valuable information about customer preferences and businesses can improve customer satisfaction and build better relationships with their customers. Retailers can use the information to better tailor their products to their customers.

Company Case Studies

IBM's comprehensive IoT solutions are used by many industries around the world. IBM's IoT system has been implemented in numerous sectors, including manufacturing floors, energy grids, healthcare facilities, and transportation. Some of the largest companies in the world have successfully incorporated the IBM Watson IoT platform. Below are two examples of its application in the retail sector.

Harnessing analytics to deliver a smarter shopping experience

Sensitel, an applications and data analytics company based in Santa Clara, California, tried to tackle a challenge that several of their retail customers experienced. Many shoppers chose to visit brick-and-mortar stores for the ability to discuss products with a sales assistant but often they could not find one fast enough, and ended up leaving frustrated

123. IBM Watson Analytics for Social Media, IBM.

124. Using the Personality Insights Service, IBM.

125. Personality models, IBM.

and empty handed, and the store missed out on a sale. Sensitel chose to partner with IBM to develop a IoT offering based on sensors, Wi-Fi and video data to recognize shoppers' faces and track them throughout the store. This allows retailers to identify and prioritize customers requiring assistance dispatching staff and being able to make personalized offers. IBM and Sensitel estimates that sales are increased by 5 percent for every 10 percent increase in staff engaging with customers.[126]

Lowering maintenance costs using predictive analytics for enterprise asset management

Migros, the largest retail company and supermarket chain in Switzerland, looked at IBM to help them optimize their maintenance practices. Migros has thousands of refrigerators which when malfunctioning can compromise the food quality and safety and, in turn damaage the company's reputation. The company receives up to 70 reports of faulty refrigerators every day. Using IBM asset management solutions, Migros was able to get a better understanding of the type and frequency of equipment breakdowns. This allowed them to make repairs faster by allocating tasks more sensibly between technicians using techniques such as skill matching, maintenance teams location, and work schedules. The ability to dispatch the right personnel, to the right asset, at the right time helped Migros cut maintenance costs and equipment downtime. [127]

Relative strength in the Marketplace

IBM Watson cognitive computing ability can bring huge benefits for companies all over the world. Large organizations have already implemented IBM cognitive computing technology to boost their profits and improve customer experience. Tools like IBM Watson analytics are equipped with predictive analysis and data visualization tools that can help organizations make critical business decisions with ease. The usefulness of IBM Watson is growing and it has been successfully applied in education, retail, government, banking, insurance, telecommunications, and nonprofit sectors.

Since the usefulness and applicability of IBM Watson is growing, it is predicted by John Kelly, the senior VP for solutions portfolio and research, that cognitive computing could reach 1 billion in sales.[128] Stephen Gold, VP for Watson, mentioned that more than 77,000 active developers are using Watson tools.[129] IBM mentions that 100 companies are selling products developed by IBM Watson platform.[129] This is a clear indication that the market is growing fast for IBM Watson.

126. Sensitel Harnessing analytics to deliver a smarter shopping experience, 2016, IBM.

127. Migros Zurich Lowering maintenance costs using predictive analytics for enterprise asset management, 2015, IBM.

128. Watson Set to Become `Huge Engine' for Sales, IBM Executive Says, September 24, 2015, Bloomberg Technology.

MAIN PLAYERS

APPLICATIONS:
SMART HEALTHCARE

Smart Hospital

Patient wristband

Patient wristband carries critical health information that can be checked at any time to increase safety and prevent life-threatening situations

Asset tags

Smart tags are attached to assets, allowing users and managers to track their use and location in real time

Smart inventory

Smart inventory systems track current stock levels across the supply chain, automating the ordering process and adjusting the quantity based on many factors including future demand estimation, expiration dates for current medicines, etc...

Item label tag:

RFID tags permit tracking of various tools and medicines, alerting staff to dangerous scenarios (e.g. exposure to specific environmental conditions) that could jeopardize the drug's efficacy and expiration date

Remote monitoring

Healthcare professionals can remotely monitor at-risk patient biometrics

Bed Touchpad

Patient information is provided by each bed and directly connected to the patient smart wristband

Clean Beds

Smart IoT-powered beds know when they are free and clean communicating it in real time

Doctor has arrived

Beacons detect as patients, doctors, and staff enter and leave each room.

Employee badge tags

RFID employee badge tags track personnel location throughout the day

Remote monitoring

Non-critical patients can leave the hospital to coalesce at home while enjoying active remote monitoring through wearable healthcare devices

Implantable Devices

Patients can be alerted when they should take their medication, get in touch with their physician or even have their medication automatically delivered by their implantable or wearable devices

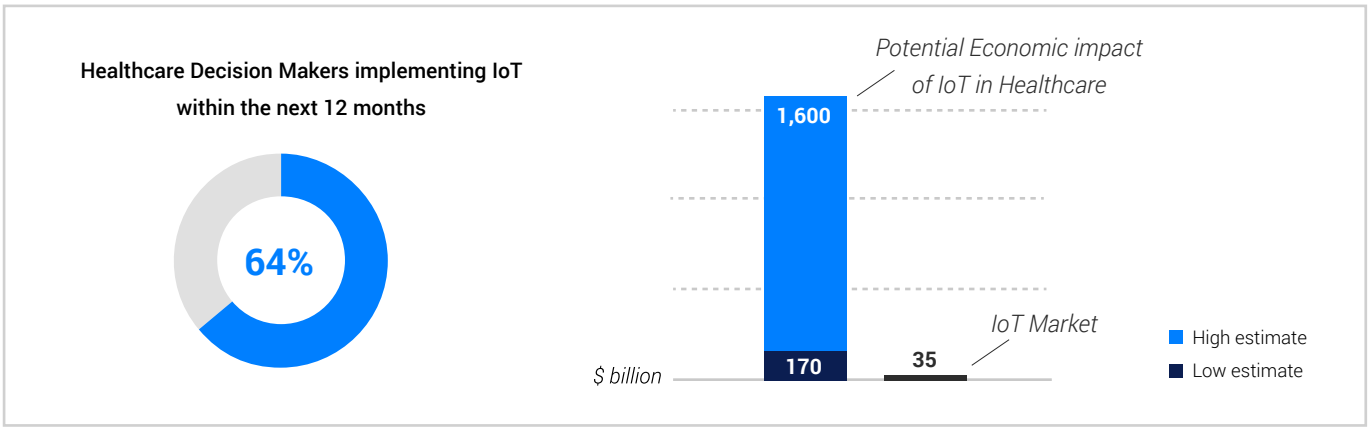
MARKET INFO

The IoT in healthcare presents a unique opportunity to have a meaningful and long-lasting impact on quality of life. While integrating the IoT in the hospital setting can lead to several interesting scenarios, the IoT takes a step forward by bringing the hospital to the patient by employing wearable sensors that allow healthcare providers to remotely monitor patients.

The healthcare sector is clearly invested in exploring the IoT. In a recent survey, 64 percent of the decision makers within the sector declared they were either in the process of implementing or would be implementing an IoT solution within the next 12 months. [129]

The potential economic impact is one of the largest we've analyzed, with a conservative estimate of $170 billion and a potential high of $1.6 trillion globally by 2025 by extending lifespans and reducing the cost of treatment.[130] Just by improving an IoT user's health, the social benefits alone could be worth more than $500 billion per year.[2]

While some stakeholders are invested in deploying IoT, adoption is not growing as fast as expected. Concerns from medical professionals, ranging from privacy assurances to a lack of understanding of the safety of these devices, have kept potential adopters at bay. A recent survey showed that only 15 percent of physicians are discussing wearable devices with their patients.[131] The high initial cost per patient has made some providers wary in the past even when the devices have been proven cost effective. Nevertheless, the latest technological developments to improve the way devices communicate and power themselves were well received in healthcare. Furthermore, these can unlock significant savings for providers. Medicare estimates that $17 billion in readmission costs could be avoided by using these types of devices.



Left, Industry decision makers insight into IoT [68]. Right, Estimated potential impact of IoT applications by 2025 (Low estimate - dark blue, High Estimate - light blue)[69] and IoT market size by 2020.

129. Internet-of-things Solutions Deployment Gains Momentum Among Firms Globally, 2014, Forrester.

130. Unlocking the potential of the Internet of Things, June 2015, McKinsey & Company.

131. Healthcare Providers: Invaluable Driver for Mobile Health Product Adoption, June 18, 2015, MedPanel, LCC.

More smart medicines have been seeking regulatory approval, potentially signaling the rise of the IoT in healthcare. An indicator of this is the increase in joint ventures between the pharmaceutical industry and technology companies recently. Some examples include the collaboration between Johnson & Johnson and IBM to develop advanced data analysis toward personalized patient engagement solutions, the Google and Novartis initiative to develop smart contact lenses, or the GlaxoSmithKline and Qualcomm deal said to be worth $1 billion toward the development of bioelectronics devices — all announced in late 2015 or the beginning of 2016.

A look at the market for technologies, applications, or services that rely on the IoT forecasts a growth of over 38 percent CAGR within the next 4 years, to a projected total of $163.2 billion by 2020.[132] Wearable devices are expected to maintain their dominance within the sector.[133]

A few big names, such as Microsoft, Cisco, IBM, and Philips, appear to dominate the scene and a continued investment in research and development toward the development of new IoT solutions is expected.

WHAT IS SMART HEALTHCARE?

WHAT DOES IT ENABLE?

Smarter healthcare provided by the IoT can impact patients by allowing them better care and less hassle while also equipping providers with better tools to manage, treat, and follow-up on their patients' recovery. The most exciting IoT enabled tools are wearables. These devices are worn or carried by a patient, like fitness bands that track heart rate. Implantable devices, on the other hand, are connected or inserted inside the body. Implantable devices offer the opportunity to not only dispense the right dosage of medication at the

132. IoT Healthcare Market by Components, Application, End-User - Global Forecast to 2020, October 2015, Markets and Markets.

133. Internet of Things (IoT) in Healthcare Market Analysis By Component, B application, by end-use and segment forecasts to 2022, May 2016, Grand View Research.

required time but also can also be easily controlled and adapted by the physician as they follow the patient's situation. This advancement can drastically change the quality of healthcare for a majority of patients with chronic illness. The World Health Organization estimates that approximately 50 percent of patients with chronic illness do not take their medications as prescribed. Smart devices can go a step further; a smart wearable insulin pump can measure blood sugar levels and automatically apply insulin when needed, minimizing large fluctuations in a patient's blood sugar. The same principle can be applied to other devices, monitoring other complex diseases that would typically require the patient to wait for a blood test or consultation before receiving potentially life-saving medication.

Another major breakthrough in healthcare is in mobile health monitoring. This shifts the focus of healthcare from acute care to early intervention and can lead to a reduction in costs by addressing health risks before they turn into a chronic disease. This can help reduce patients' time in the hospital and greatly increases their chances for recovery. Physicians have access to patient information in real time, get warnings if values go above certain thresholds, and can decide on the best action to take, based on their knowledge of patient history, whether it's prescribing a new medication or requesting the patient come in for further testing or medical intervention. This can also help optimize resources and spending by healthcare providers. The average cost per inpatient stay has continued to rise across the U.S., with some state and local government hospitals spending over $3,000 per day.[134] The ability to monitor patients remotely allows for low risk patients to be discharged from the hospital to recover at home, which can be a safer environment due to the high rates of hospital infections, while also saving hospital resources for the patients who truly need it. [135]

Hospitals themselves can benefit from the IoT. Medical staff deals with different issues, like equipment use, inventory management, or available personnel. Even for a small medical center, the inefficient management of these resources can be a financial burden — a potentially life threatening one. Similar to the retail environment, smart tags and sensors could improve inventory management by preventing overstocking, which, due to short the expiration dates of some medicines, leads to waste. Medical equipment connected via the IoT would let the whole hospital know the schedule and current use, minimizing downtime, as well as allowing for overrule in an emergency. Patient data can be connected directly from the equipment performing the exam, freeing medical professionals from time-consuming data entry, and eliminating user error. With an IoT connected hospital, both patients and emergency services know where they should go.

The adoption of IoT by the healthcare sector will lead to an explosion in patient data. The ability to access this data and explore it can make personalized and predictive medicine a reality. The variability of genetic, clinical, and other exogenous factors has always created a challenge to the pharmaceutical sector. Drugs are created to target the average patient, by combining

134. AHA Annual Survey Database™, 2015.

135. HAI Data and Statistics, Centers for Disease Control and Prevention.

this data with how patients respond to different drugs and dosages, we can provide more accurate medications and improve the drug discovery process by.

KEY TECHNOLOGIES

MINNETRONIX

MINNETRONIX®
THINKING MEDICAL SYSTEMS®

Minnetronix was founded in 1996 by former 3M engineers. It designs and manufactures devices for a wide range of medical applications and treatments. They promote an integration of development issues such as ideas and innovation, regulatory issues, strategic concerns, quality assurance, design and engineering, and manufacturing operations.

Approach to IoT

The company's initial project was the development of a software driven controller for a total artificial heart (ETAH). This federally-funded program was a joint effort between 3M Cardiovascular Systems Division, Penn State University, and Minnetronix, and helped lay the groundwork for the company's technology direction and rapid business growth.[137] Their experience with collaboration is valuable because it's is a critical component of technology development in this sector. In 2016, Minnetronix received a $20 million investment from Altaris Capital Partners to support growth initiatives. Minnetronix, an employee-owned company with 200-plus workers that earned more than $60 million in revenue in 2015, said the investment by Altaris is the first outside equity it has raised since its founding 20 years ago.[138]

Dirk Smith, Minnetronix co-founder, encapsulates the key aspect of Minnetronix' approach to the Medical Internet of Things (MIoT), "Combine solid medical device development fundamentals with industry expertise in connectivity technology." [148] An insight he believes medical device manufacturers should ask when weighing the benefits of integrating connectivity and wireless into their products.[138] Minnetronix aims to take advantage of the current explosion of connected devices that make up the IoT. Medical devices are poised to take advantage of the readily available wireless technologies in support of connectivity. Minnetronix can play a big role, bringing its expertise in wireless, cellular connections (similar to those used by cell phones) to the medical field.

Wireless connectivity in medical devices can enable better outcomes at reduced costs. Potential implementations could be hospital-based electrosurgical generator, therapeutic home care devices, clinic-based ophthalmology diagnostics, lab-based embedded hospital equipment, pay-per-use and automated billing, outcome tracking, extending the reach of clinicians through real-time information, and clinical trial data collection.

137. Minnetronix Raises $20 Million in Equity Capital to Support Growth Initiatives, January 26, 2016, Minnetronix.

138. Beyond the Hype: Integrating Connectivity and Wireless into Medical Devices, 2016.

Minnetronix is aware of the challenges the industry currently faces, among them incorporating radios into medical devices, development and scalability, system architecture, and standards and licenses. The organization appears to be focused on continuing to develop IoT devices within the sector and is mindful of the challenges and benefits the IoT can provide.

Areas of expertise

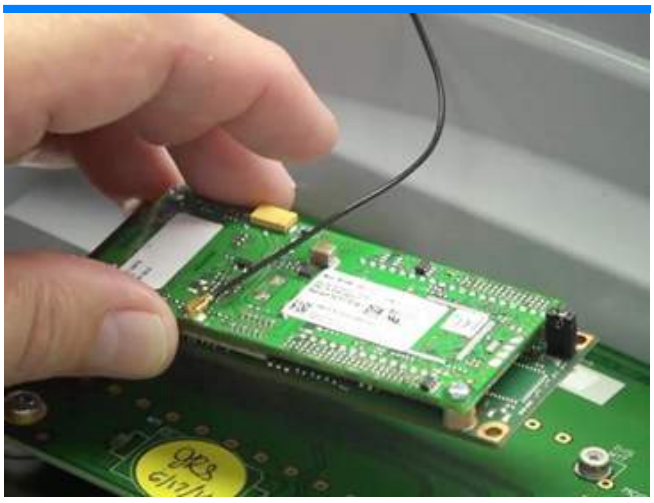
Minnetronix describes six areas of expertise that constitute a valid systems approach, which emphasizes integration in product development.

- **Ideas and Innovation** – This area focuses on the development and protection of intellectual property. It also draws upon the existing IP of Minnetronix.
- **Strategic Options** – This area that these folks on methods of intellectual property generation, including new business models and partnerships.
- **Quality Assurance and Regulatory Expertise** – These areas focus on mitigating risk and compliance with FDA and international regulations.
- **Design and Engineering** – Minnetronix' experience in software, electronic, and mechanical design across medical applications is illustrated by their device portfolio.
- **Manufacturing Operations** – This area emphasizes Minnetronix' existing range of manufacturing facilities and services.

Device Portfolio

Minnetronix' proprietary technologies and therapies can decrease development risks and increase speed to market. There are several technologies offered by Minnetronix that may contribute to a shorter length of stay, less utilization of hospital resources, improved clinical functional outcomes, and an overall reduced healthcare economic burden — among these are:

- The Cognita™ Control that provides customized power and control technology for ventricular assist devices
- A cerebrospinal fluid treatment platform is technology in development that provides an alternative for treating neurodegenerative and life-threatening diseases that involve foreign bodies in the cerebrospinal fluid.



Cognita™ Platform

The Cognita™ Medical Device Connectivity Platform provides a customizable hardware, software, and systems solution to remote medical device connectivity. This Minnetronix technology represents a stretch from the realm of medical device development into the realm of medical device connectivity and the IoT.

The approach of Minnetronix is worth consideration, as they have a background in developing medical devices and are capable of modifying hardware in order to accommodate data transmitters. This is a valuable link in the MIoT network.

The development of Cognita was motivated by the need of manufacturers for real-time communication with their fleet of devices. It consists of cost-effective, customizable technology that can be built into medical devices and platforms for assembling the data streams from connected devices.

Relative Strength in the Marketplace

In late January 2016, Minnetronix raised a $20 million stake from Altaris to help bring to market its first proprietary product. Also, early in 2016, Minnetronix and BioSig Technologies, a development stage medical devices company with a $9.46 million net income in 2015, announced a development partnership. When asked why BioSig chose to partner with Minnetronix, the CEO of BioSig stated, "Minnetronix has a long history of successfully partnering with companies in the development of complex medical technologies."[139]

The IoT in medicine is a burgeoning area, it can be applied to electronic medical records and health information systems from admission, to discharge, to billing, as well as mobile and remote health and wellness applications. Minnetronix is leveraging their expertise in manufacturing medical devices in their approach to MIoT.

139. Interview with Greg Cash, President and CEO of BioSig Technologies (BSGM), April 14, 2016, Microcap Research.

PILOTFISH

Applied PilotFish Healthcare Integration, Inc. (APHII) is a healthcare subsidiary of the parent company PilotFish Technology, founded in 2001. PilotFish Technology develops middleware to enable the integration of disparate systems. Applied PilotFish distributes PilotFish products directly, and through select channel partners, to healthcare sector end-users. APHII is focused solely on enabling interoperability within the healthcare ecosystem and offers a suite of products. [140] With a focus on focus on Java, J2EE, XML, Web Services and related e-commerce technologies, Pilotfish's many offerings help customers and businesses connect devices and facilitate communication between them.

Approach to IoT

PilotFish offers modern and robust solutions that enable data integration between any systems, applications, databases, operating systems, and platforms, notwithstanding the need to support the latest new technology, legacy systems, or both. Their focus is on integrating the data output from assorted devices into a unified display.

PilotFish presumes the value and connectivity of devices, however, they are aware that "plug and play cannot be achieved in the near future. In healthcare, there are too many legacy and disparate systems, too many standards and too much customization."[141] PilotFish middleware purports to handle the differences in data formats, the extended versions of standards, and the different "flavors" of standards.

Areas of expertise

PilotFish focuses on their methodology and emphasizes that this approach has the potential to do for medical devices and communication what the assembly line did for the automobile.

Technical specifications

PilotFish offers built-in support for all versions of HL7® 2.x, 3.x, extended and non-standards compliant versions including the new FHIR® standard; DICOM, CCD/CDA, CCR, and EDI. A native XML support ensures you can handle any future healthcare standard.

It is necessary for PilotFish to accommodate the broadest range of products and variety of protocols. The following is a list of PilotFish product specifications:

140. Featuring the Automated Interface Assembly Line, PilotFish.

141. PilotFish Methodology, PilotFish.

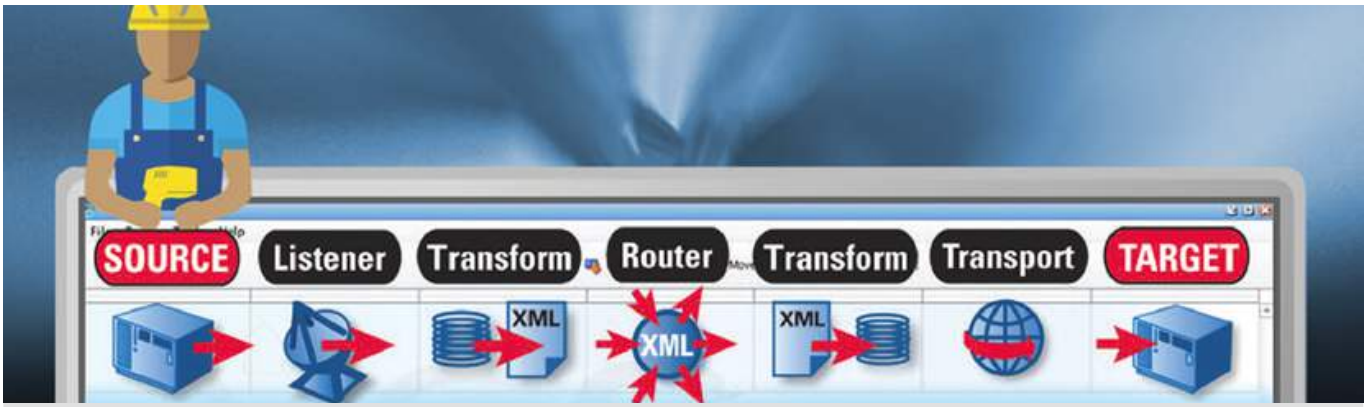


FIGURE 3: The PilotFish Automated Interface Assembly Line

- **Supported platforms** – Windows, Linux, Mac, Unix, AIX /HP-UX
- **Supported application servers** – Apache Tomcat, Glassfish, WebSphere, JBoss, WebLogic, Windows Service / No App Server
- **Supported databases (Based on open standards)** – Microsoft SQL Server, Oracle, DB2, MySQL, PostgreSQL, Access DB, H2
- **Supported protocols** – RDBMS (all modern database systems), Email (POP3 / SMTP), Local Network File System, FTP / SFTP / FTPS, TCP / IP (including LLP), HTTP / S, Messaging (JMS / Q / MSMQ), API-Call, Java RMI, Web Services (SOAP, REST), Command-line invocation (CLI), LDAP / Directory Services, Custom Connectors, Workflow / Process Orchestration, Direct
- **Validation** – Data format conformance (XSD, HL7 spec, etc.), Business rules / Schematron, Lookup validation against, external sources, Custom validators
- **Deployment models** – Appliance / Virtual appliance, Hosted, Deploy to own server, Total / Suite solution
- **Workflow patterns support** – Sequencing, Splitting, Merging, Branching, Conditional Logic, Iteration
- **Data transformations** – Graphical, drag and drop data mapping, Codeless/Scriptless data transformations, Generates W3C compliant XSLT, Computationally complete
- **Error handling** – Passive handling for errors, including logging, database, reporting, real-time responses, Proactive handling for errors, including sending, e-mails, sending SOAP messages, Customizable logging and database reporting
- **Testing** – Graphical "Test Mode" for rapid step-by-step debugging, View the content of each stage, Skip stages or modify data in-flight, Connect to interface endpoints or bypass as required, Embedded "eiPlatform emulator"
- **Supported standards** – HL7 2.x / 3.x / FHIR, CCD / CDA, EDI (ANSI X.12), Positional Flat Files, Delimited Files, CSV, XLS / XLSX, DICOM, Semi-Structured Text, XML, Binary (.pdf, .wav, .jpg)
- **Architecture** – Consistent "assembly line" pattern, configuration over code, component-driven, extensible via open APIs
- **Licensing model** – Installation-based licensing, end user, product bundling and reseller licenses

Device Portfolio

Applied PilotFish Healthcare Integration, Inc. (APHII) offers several products focused on healthcare integration, including:

- **eiPlatform Interface Engine** – Java framework that leverages application server technology, web services, industry XML, and other healthcare standards.
- **eiConsole for Healthcare Integration IDE** – Healthcare Interface Engine IDE (Developer's Workstation) that is codeless and scriptless, featuring a "self-documenting" Assembly Line and a true graphical, drag and drop, universal Data Mapper.
- **eiDashboard** – Monitors the performance of the eiPlatform and provides a wealth of Business Intelligence (BI) information.
- **HealthConnect** – An application for iPhone or iPod (iOS8 or higher) that facilitates integrating any HealthKit enabled medical device.
- **eiPortal** – A cloud-based solution that provides all of the resources required to establish standardized initial and ongoing healthcare information exchange.
- **PilotFish Interface Exchange (PIE)** – An online marketplace for eiConsole interface templates and components. Allows users to download, share, publish, and distribute eiConsole interfaces on the PIE.

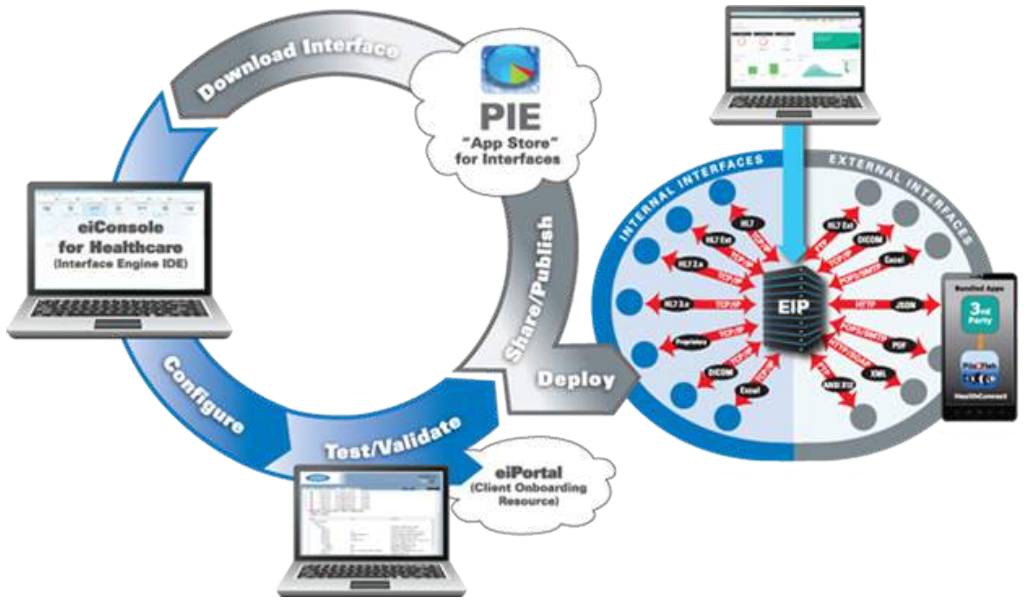


FIGURE 4: PilotFish Supports interoperability across medical landscape. [142]

142. Integration Engine Solutions To Meet the Needs of Any and Every Healthcare Entity!, PilotFish.

Company Case Studies

Gamma-Dynacare

Gamma-Dynacare is one of Canada's largest and most respected providers of laboratory services and solutions. Their clients include 9 million patients, more than 15,000 healthcare professionals, governments, regional health authorities, hospitals, long-term care facilities, clinical trial sponsors, employers, insurers, and other laboratories. The PilotFish Interface Engine solution was selected to manage the high volumes of data and disparate requirements of these clients. According to David Brajkovich, Director of Business Applications Development at Gamma-Dynacare, "In metrics, we are finding that by leveraging PilotFish solutions, interfacing time has decreased by 50 percent." [143]

Metro®

In 2014, Metro®, a manufacturer and supplier of storage and transport products in the foodservice, commercial, and healthcare industries with an estimated revenue of less than $1 million, partnered with Applied PilotFish Healthcare Integration. According to Bob Moore, Director Software Solutions at InterMetro, the PilotFish product suite can "interface with the array of IT systems found in healthcare to meet the evolving federal meaningful use mandates." Metro's healthcare products include AccessPoint™ and Flo® computer carts, AccessPoint™ Rx MD mobile medical dispensing carts, AccessCenter™ and MedDispense® automated dispensing machines, and MetroMount™ wall-mounting systems.

In 2016, TouchPoint Inc., a business unit of the Ali Group based Concordville, Pennsylvania, bought the Health Care Technology business of InterMetro Industries, Inc. TouchPoint formed TouchPoint Medical as a new business platform to incorporate the Metro assets and its existing successful medical technology businesses. TouchPoint Medical owns ITD, a global leader in stationary and mobile carrier systems for medical technology, as well as Vanas Medical Storage Solutions and Mediwell Systems, Ltd.

Relative strengths and Future outlook

Applied Pilot Fish Healthcare Integration, Inc., focuses on the software communications of various medical devices using communications protocols. The future of APHII in this realm is excellent, depending on the ongoing use of communication protocols by medical devices and the need for integration of their data output. According to APHII, "Our native XML support ensures you can handle any future healthcare standard." [144]

In 2015, PilotFish integrated all Android and Apple medical devices into a system — meaning that they are platform agnostic. Also in 2015, APHII officially announced support for the new FHIR (Fast Healthcare Interoperability Resources) standard, developed under the HL7 organization. In addition to the technical

143. Gamma-Dynacare Selects PilotFish's HL7 Interface Engine Solution to Support Strategic Integration Initiatives, March 16, 2013, Healthcare Scene News.

144. The eiPlatform Interface Engine – A Modern Solution to Healthcare Integration, PilotFish.

benefits of the standard, FHIR addresses "real world" needs, such as mobile healthcare applications in the cloud, mobile device integration, and more flexible, custom workflows. Key to PilotFish's success is their agnostic approach that allows the development of enterprise solutions without the constraints of proprietary systems or platforms.

GE PREDIX

General Electric Company (GE), incorporated in 1892, is a global digital industrial company. With products and services ranging from aircraft engines, power generation and oil and gas production equipment to medical imaging, financing and industrial products, GE segments include Power, Renewable Energy, Oil & Gas, Energy Management, Aviation, Healthcare, Transportation, Appliances & Lighting, and Capital. GE Predix, the operating system for the Industrial Internet developed by GE, aims to power digital industrial businesses by connecting industrial equipment, analyzing data, and delivering real-time insights.

Approach to IoT

GE Healthcare, the $18 billion healthcare technology division of GE, announced in 2015 that it would invest $300 million as part of a multi-phase effort to develop a more robust affordable healthcare portfolio for customers. [145] They have announced plans to enter the cloud services market, GE Health Cloud is designed exclusively for the healthcare industry and is built on GE's industrial-strength Predix™ platform. This platform-as-a-service (PaaS) is set to capture and analyze the unique volume, velocity, and variety of machine data within a highly secure, industrial-strength cloud environment. According to the company, it is designed to address the unique requirements of the healthcare industry, including managing the volume, velocity, and variety of healthcare data, such as complex 3D imaging data, in a secure, HIPAA-compliant, and "gated community" cloud environment. "Cloud computing has enabled incredible innovation across the consumer world. With Predix Cloud, GE is providing a new level of service and results across the industrial world," said Jeffrey Immelt, CEO of GE, "A more digital hospital means better, faster healthcare"[146]

GE Predix Health Cloud has several features, including:[146]

- **Asset Connectivity** – Predix Health Cloud provides advanced connectivity-as-a-service for these assets, collaborating with global telecommunications partners to enable rapid provisioning of sensors, gateways and software-defined machines.
- **Scalability for Machine Data** – Predix Health Cloud is designed to store, analyze, and manage machine data in real time, such as delivering large object data like 3D MRI images to a doctor for diagnosis.
- **Security and Compliance** – Predix Health Cloud

145. GE Announces Predix Cloud – The Worlds First Cloud Service Built for Industrial Data Analytics, August 5, 2015.

has advanced security protocols available, such as customized, adaptive security solutions for industrial operators and developers.

- **Governance** – Predix Health Cloud is designed to streamline governance and drive down compliance costs for each individual user, while respecting national data and sovereignty regulations globally.

Technical specifications regarding GE Predix Health Cloud technology

The GE Predix Health Cloud is designed to offer an integrated analytics and visualization engine and will connect to hundreds of medical devices and machines from multiple vendors, including the more than 500,000 GE Healthcare imaging devices. Leveraging built-in support for healthcare IT interoperability standards like FHIR, HL7, and DICOM, and full attestations for HIPAA compliance including HITECH and HITRUST, the GE Health Cloud will be a scalable, secure, interoperable platform.

Through its app store, the GE Health Cloud will deliver a set of applications that will help to facilitate improved clinical, financial, and operational outcomes. Predix's communication technologies include direct Internet connectivity. When the Internet is not available, Predix offers a virtual network, including cellular and satellite technologies.

GE Health Cloud will offer the following services:

- **Centricity Cloud Advanced Visualization** – This service is designed for image post-processing of advanced 3D images, enabling access to non-diagnostic 3D advanced imaging tools.
- **Centricity Multi-Disciplinary Team Virtual Meeting** – This service will provide participants with centralized access to patient data.
- **Centricity Case Exchange** – Will enable affiliated and non-affiliated physicians to share images and collaborate within existing workflows.
- **Centricity Image Access Portal** – Will provide affiliated and non-affiliated clinicians access to a longitudinal record of their patients' imaging data. With role-based access, remote clinicians can immediately see studies and reports as the radiologist completes them, helping to improve turnaround times and strengthen referral relationships.

GE Healthcare also announced six new analytics applications that are being developed internally to be hosted on the GE Health Cloud. These apps are targeted to help clinicians in various departments across the healthcare enterprise, including hospitals, health systems, and physician practices.

- **Centricity Insights for Financial Management** – An advanced set of analytics designed to help healthcare systems reduce claims denials and related re-work costs. DenialsIQ uncovers hidden patterns within claims denials so that administrators can proactively fix them. This system helped one customer reduce denied charges by 47 percent, saving $93,000 in re-work costs in one month.
- **Centricity Insights for Intensive Care** – A system that uses patient data such as age, weight, whether they are a smoker, have diabetes, and time spent on the ventilator to create a digital twin

of the patient. They use the information to help clinicians predict the average length of stay for that patient in the ICU (Intensive Care Unit) and the probability that the patient will have specific further complications.

- **Radiology Insights for X-ray Repeat or Reject Rates** – Intended to help reduce repeat or reject rates by using machine data to track and trend the rates and identify follow-up training needs.
- **Radiology Insights for Modality Utilization** – Will use machine data to track modality utilization across a region or hospital system to help care delivery networks optimize the use of their modality assets.
- **CortexID Suite** – Will provide insights to physicians in the image interpretation process of amyloid PET studies conducted on patients being evaluated for cognitive impairment, or other causes of cognitive decline, and serves as an adjunct to other diagnostic evaluations.
- **Centricity Insights for Materials Management Optimization** – Will analyze healthcare provider inventory, suppliers, and the cost of materials used in cardiology, peri-operative, and interventional radiology procedures to help drive action.

Additionally, apps on the GE Health Cloud will be delivered on a subscription basis, enabling hospitals and health systems to shift computing expense to a variable cost model. The cloud ecosystem will include a robust Software Development Toolkit (SDK), and the app store will host and promote new software solutions. To help independent software vendors (ISVs) run their cloud businesses more profitably, the cloud will also include a complete billing and subscription management infrastructure. [146]

Specific information on whether GE Predix Health Cloud is offering a hardware solution, software solution or combination of both

GE Predix is designed to be a cloud-based software solution.

GE Predix Health Cloud IoT domain

GE Predix Health Cloud is a cloud ecosystem that will deliver GE Healthcare software applications "as-a-service," accessible via the Internet and offered on a subscription basis. GE Health Cloud integrates with existing clinical workflows to provide on-demand access, remote monitoring, asset connectivity, machine data support, and industrial-grade security and compliance. Users will be able to connect their imaging modalities to the GE Health Cloud to leverage advanced imaging algorithms in the cloud across the company's entire portfolio, including ultrasound, magnetic resonance, computed tomography, and positron emission tomography. A key component of the GE Health Cloud is its ability to host healthcare-specific applications developed by 3rd-party ISVs.

GE is highlighting two applications, NeuroQuant (from CorTechs Labs) and Arterys, which are both expected to be available through the GE Health Cloud in 2016. NeuroQuant is a quantitative magnetic resonance solution that automatically segments and measures volumes of the hippocampus, ventricles, and other brain structures and compares these volumes to norms, reducing the subjectivity of the diagnosis

process. Arterys software allows large datasets to be evaluated in real-time and reduces the amount of time spent on data processing and new visualization tools. This includes ViosWorks, a cardiac magnetic resonance imaging solution that captures seven dimensions of data (three in space, one in time, three in velocity direction) to deliver a three-dimensional spatial and velocity-encoded dataset at every time point during the cardiac cycle. The free-breathing scan, typically acquired in less than 10 minutes, yields high resolution, time-resolved images of the beating heart and a measure of the speed and direction of blood flow at each location. [147]

Company Case Studies

Three large companies announced plans to build customized apps for their customers using the GE Health Cloud.

Capgemini has a long-standing relationship with GE Healthcare. Having provided connected healthcare and visualization solutions across several clinical specialties, Capgemini will leverage its business and digital expertise to provide consulting and end-to-end solutions for Predix.

Tata Consultancy Services (TCS) will leverage its business, digital, and healthcare IT expertise to develop new applications on the GE Health Cloud platform. An existing partner of GE Healthcare and GE Digital, TCS will offer end-to-end solutions to customers. TCS will leverage its consulting experience to ensure quality control and regulatory compliance in these new applications.

Arterys, Inc., also has a long-standing relationship with GE. The company specializes in deep learning applied to imaging, beginning with the heart, providing accurate quantification of blood flow and clinical visualization. "Leveraging the GE Health Cloud, we look forward to developing next generation solutions that utilize our proprietary quantification and visualization algorithms together with deep learning to advance diagnostic imaging capabilities in neurology, oncology, and many other areas of healthcare," said Fabien Beckers, Ph.D., Founder and CEO of Arterys. [148]

Relative strength in the Marketplace

GE Health Cloud announced a promising beginning, as two large systems integrators and seven leading-edge ISVs are planning to move their innovative digital solutions to the new GE Health Cloud. It is estimated that GE Health Cloud will ultimately connect more than 2 million imaging machines worldwide, including 500,000 GE Healthcare devices. Although GE Health Cloud targets a global market, its future efforts might be geared toward developing countries, which continue to invest in effective, long-term healthcare solutions to improve the health of their populations.

147. RSNA 2015: GE launches Health Cloud for clinical collaboration with fee for service apps, December 3, 2015, Applied Radiology.

148. GE Health Cloud Welcomes New Partners, New Apps to Ecosystem Connecting 2 Million Imaging Systems Worldwide, March 1, 2016, Business Wire.

CHRONO THERAPEUTICS

Chrono Therapeutics Inc., founded in 2003, is pharmaceutical company created by Guy DiPierro. Chrono aims to revolutionize the way addictions and diseases are treated, by enabling programmable passive transdermal drug delivery with real-time behavioral support. The company's wearable technology tailors the timing and dose sizes of drugs, preempts predictable peak disease, and addiction symptoms with a device.

Approach to IoT

Chrono Therapeutics has gathered around $80 million in funding from 9 investors over 3 funding rounds, the most recent was held in September 2016 and accounted for almost $50 million in funding.[149]

With the help of four technologies, Chrono Therapeutics is positioning itself to revolutionize the way drugs are delivered to patients. The platform provides a totally new approach to patient medication by allying biologically-timed drug delivery, compliance measurements, behavioral support, and data analytics in order to provide custom-made drug treatments to patients with nicotine and opioid addictions or suffering from diseases like Parkinson's or chronic pain.

Product specifications

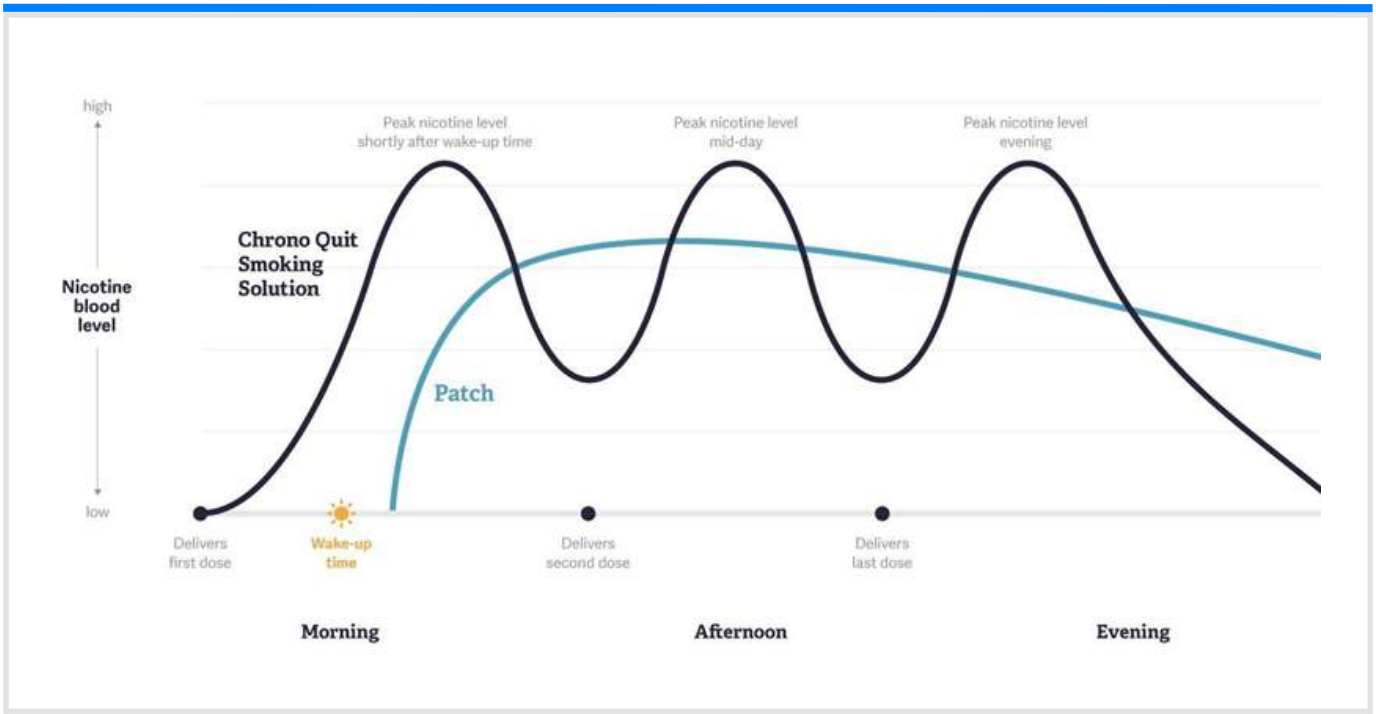
By equipping a transdermal patch with a smart sensor, drugs can be administered in different quantities throughout the day to provide the best results.

The first application of this new technology is in smoking cessation or nicotine addiction. The patch is allied with a "crave button," and a smartphone application with coaching and data analytics capabilities, the intelligent transdermal patch can minimize nicotine cravings.

Biologically-Timed Drug Delivery

The smart device optimizes the dosage to follow a regular daily pattern, learning when the strongest cravings are fought, such as first thing in the morning or after meals.

149. Chrono Therapies, Crunchbase.



Daily Use and Compliance Measurement

The smart device was developed to be lightweight, comfortable, and discreet. This allows the user to wear the device without anyone else noticing.

Each cartridge is developed to last 24 hours, making it ideal to change once a day, on a regular schedule, such as at bedtime. The nicotine delivery treatment is also a step program with different levels, to help make quitting easier.

Data Analytics

Detailed data on nicotine delivery and the usage of the wearable and app are analyzed, and together with the intelligent nicotine delivery and coaching algorithms, adjust the program to a users' specific needs.

User data is later de-identified and used to help third parties for the administration of smoking cessation treatment, programs, and benefits.

Behavioral Support

Chrono Therapeutics has collaborated with experts from the Mayo Clinic and Fred Hutchinson Cancer Research Center to develop cutting-edge behavioral change science.

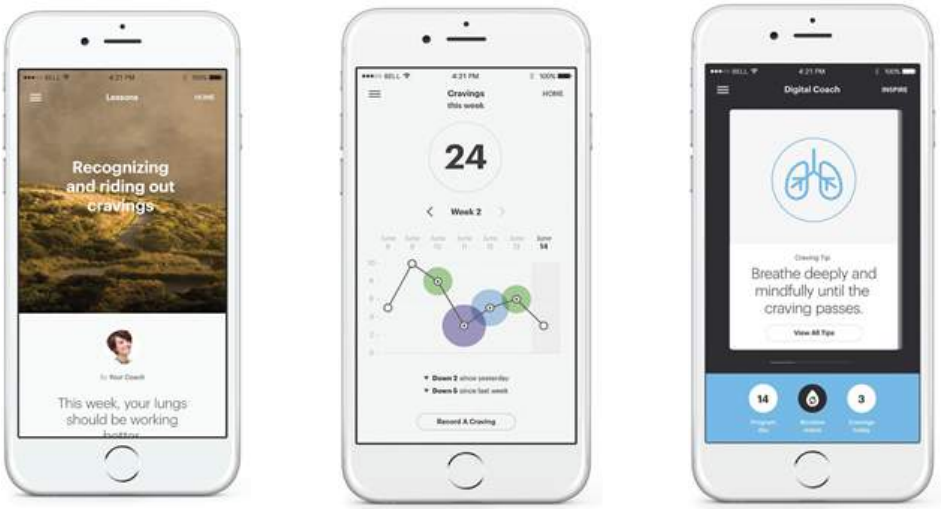
Tools such as reminders, real-time device status, coaching, insights, patterns, and motivation help the patients through the process, making it a more efficient and personalized experience.

Pharmaceutical IoT Market opportunities

Chrono Therapeutics aims to enter this market by first addressing tobacco addiction problems and later expand into new markets by applying their technology to other addictions and diseases.

The company opted for smoking cessation for it's first step because according to the US Centers for Disease Control and Prevention (CDC), cigarette smoking kills more than 480,000 people just in the US each year. Adding to that, smoking related illness costs over $300 billion a year and the CDC estimates that 40 million adults in the US are cigarette smokers. [150]

Their business model takes into account that under the Affordable Care Act, FDA approved smoking cessation products are reimbursed. Also, many large companies provide smoking cessation support programs for their employees that include medications. This has become more common since studies have shown that each employee that quits smoking saves companies around $6,000 a year, half in healthcare costs and the other half in productivity costs. [151]



150. Burden of Tobacco Use in the U.S., Centers for Disease Control and Prevention.

151. Estimating the cost of a smoking employee, June 3, 2013, Tobacco Control.

Relative Strength in the Marketplace

Chrono Therapeutics counts over a dozen partners ranging from tech companies to healthcare providers, such as General Electric and Mayo Clinic. Together with their partners, Chrono aims to revolutionize the drug administration process by expanding to address opioid addiction and diseases like Parkinson's or chronic pain.

Patients with diseases like Parkinson's would receive many advantages from automatically timed drug delivery since they often experience muscle stiffness when they wake up and delivering the drug an hour before waking could fight the difficulties some patients getting out of bed in the morning.

Their nicotine addiction treatment is currently in clinical trials and pending FDA approval. Chrono also aims to be the first FDA approved treatment for opioid addiction.

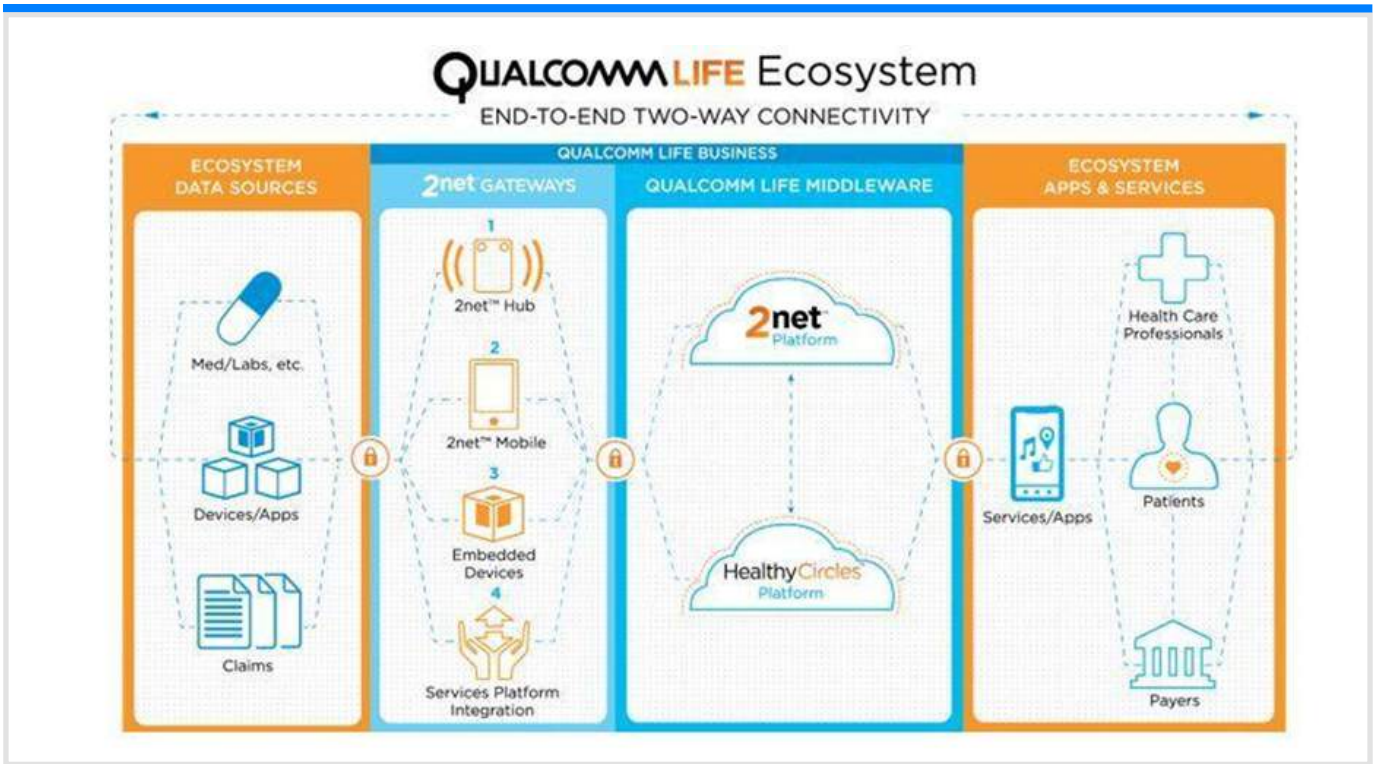
QUALCOMMLIFE

Qualcomm is an American multinational company that develops wireless technologies. The company is headquartered in San Diego, California, and has 33,000 employees in 224 worldwide locations. In 2015, the total equity of Qualcomm was $31.4 billion, and their revenue was $25.3 billion. Qualcomm develops, "the connectivity fabric and chipsets for the IoT, which will link 26 billion objects over the next five years."[153] The scope of Qualcomm includes wireless telecommunications and related services.

Connected wireless technologies in the field of healthcare are the domain of QualcommLife, Inc., which emphasizes the integration of medical devices and clinical data management. A significant feature of QualcommLife is the development of an ecosystem consisting of over 200 medical device and data companies. In late 2015, QualcommLife acquired Capsule Technologies, which is focused on medical device integration and clinical data management either in the home, in the hospital, or any point in between.

Qualcomm has established a series of collaborations with pharmaceutical and medical devices companies, allowing them to fully explore the power of the IoT on their devices. In 2016 alone, Qualcomm announced collaborations with Philips, Boehringer Ingelheim Pharmaceuticals, Medtronic, UnitedHealthcare, and Novartis to develop different connected healthcare solutions.

153. Qualcomm Life.



Qualcomm Life IoT products and technology

QualcommLife aims to address unsustainable health system costs due to readmission and institutional care by developing models that safely manage at-risk patient populations in remote care settings. Not all patients suffering from chronic medical condition require hospitalization, if reliable remote alternatives were available. Today, 71 cents of every dollar of U.S. healthcare spending goes to treating people with multiple chronic conditions.[154] Furthermore, Medicare estimates that $17 billion in readmission costs could be avoidable. [155]

QualcomLife's medical-grade 2net platform is at the heart of remote care, allowing patients to "admit at home" and reduce rates of readmission.

154. Multiple Chronic conditions Chartbook, 2010, AHRQ.

155. Conditions With the Largest Number of Adult Hospital Readmissions by Payer, 2011, April 2014, HCUP.

Device Portfolio

Qualcomm Life offers several means of wireless communication among devices, integration of wireless mutations, and related services:

- A plug-and-play communications device that enables secure, medical-grade connectivity, and an effortless user experience.
- Integrating with wide- and short- range radios, it offers flexible connectivity across a growing and open ecosystem of medical devices and sensors.

2net Hub by Qualcomm Life

- A medical-grade software module that can be embedded in third-party mobile applications.
- Transforming mobile computing devices, smartphones, and tablets into secure medical-grade gateways that capture, transmit, and protect data for patients at home or on-the-go.

2net Mobile by Qualcomm Life

- A scalable, cloud-based system that enables end-to-end medical device data connectivity, transmission, and integration with virtually any system, application, or portal.
- 2net Platform is an FDA-listed, Class 1 MDDS, and CE-marked Class 1 Medical Device (EU) enterprise-grade infrastructure, enabling secure sharing, and storage of vital data.

2net Platform by Qualcomm Life

Company Case Studies

Qualcomm Life has seen several deployments of both their 2net platform below are some case studies:

Cerner is a health information technology company, with products at more than 18,000 facilities in over 30 countries. Cerner is leveraging Qualcomm Life's 2net™ Platform to power their CareAware® device connectivity platform.

Entra Health Systems leveraged Qualcomm Life's 2net Platform and Hub to develop a solution that makes their MyGlucoHealth® wireless blood glucose meter easily accessible to patients with diabetes in order to expand product adoption in the diabetes care market.

King's Daughters Medical Center (KDMC) is utilizing the 2net Connectivity Platform, as well as personal health devices within the Qualcomm Life Ecosystem. KDMC is identifying at-risk populations, and implementing protocols across care settings.

mHealth Alert is leveraging Qualcomm Life's 2net Platform and Hub to remotely track a patient's measurements and alerts anytime, to reduce readmissions and the average length of hospital stay.

Propeller Health is bringing common inhalers online with a Bluetooth-enabled sensor that tracks and transmits inhaler data.

ResMed, leveraging Qualcomm Life's secure 2net Platform, offers an innovative service for remote monitoring and exception-based management of chronic respiratory disease.

Sentrian Remote Patient Intelligence (RPI) relies on Qualcomm Life's 2net solution to capture, transmit, and protect device data, making it available to care managers in a timely manner.

Triventis Health's Kraken is a Bluetooth® Smart-enabled mobile medication management system designed to assist in organizing and tracking complex, multi-pill daily regimens. Kraken leverages the 2net Hub and Platform. Triventis found that patients who enter a program utilizing the Kraken Medication Management system show an approximate 20 percent drop in their rate of readmissions.

Relative Strength in the Marketplace

The patient monitoring device market will be a significant part of the mobile health market with more patients (and their doctors) looking for novel ways to access information on their health, while freeing hospital beds. Both healthcare providers and device manufacturers will be looking to bring connectivity to their products in the future, while also hoping to learn more about their patients. Qualcomm Life is in a great place to leverage this market trend with its 2net platform. The company has announced five different collaborations with pharmaceutical and medical device companies in 2016 alone, these will be joining several others already using the 2net platform to extract and deliver the information their devices capture. Their acquisition of Capsule shows also an interest in being able to better integrate and help their clients extract meaningful data. Both traits should be highly attractive to potential partners.

ORACLE

Oracle Corporation, incorporated in 2005, provides products and services that address all aspects of corporate information technology (IT) environments, including application, platform and infrastructure. The company primarily specializes in developing and marketing database software and technology, cloud engineered systems and enterprise software products—particularly its own brands of database management systems. In 2015 Oracle was the second-largest software maker by revenue, after Microsoft.

Approach to IoT:

Medical monitoring devices that can be used at home are a cost-effective solution in an environment of rising healthcare expenses. At the end of 2013, there were 3 million patients using connected home medical monitoring devices worldwide, and it's expected that this figure is growing exponentially. Consequently, remote monitoring solutions' revenue is expected to grow to $22.6 billion by 2018.[156] Oracle's Java offers an IoT mHealth platform for improving patient care and reducing costs end-to-end.[157]

Technical specifications regarding Oracle IoT products and technology

Java and Oracle's enterprise IoT solutions work together to offer a single end-to-end IoT platform for mHealth applications. This IoT mHealth platform, which uses the ZigBee Network, can be used for medical devices, data aggregation and analytics, remote software provisioning and management, and end-to-end connectivity, all built on the industry standard Java language, which is optimized to run on resource-constrained embedded devices. The architecture covers and supports multiple applications either within a single mHealth gateway, or distributed across multiple embedded computers and devices with high-speed reliable communications. Oracle Java reference architecture supports integration with external systems through REST-ful services, embedded service oriented architecture-based web services, and secure, local storage of data.

Through this architecture, Oracle's Java delivers the following mHealth services:

- **Data management** – Filtering, analyzing, and correlating sensor data (from wearables such as wristbands, jewelry, glasses, contact lenses, and caps), supporting action on large amounts of data
- **Real-time monitoring** – For monitoring and immediate action locally, at the machine level, and the enterprise back end
- **Tooling and event flow monitoring**
- **Remote device management** – Network driven by remote device and application life cycle management

156. The Global Wireless M2M Market, BERG Insight, 2009.

157. Java and the Internet of Things: The Intelligent Platform for Healthcare, March 2014, Oracle.

- **Safety and security** – Java Embedded can support healthcare standards set forth by regulatory bodies.

Oracle believes security has to be built in at every layer of the cloud stack, and its security protocols have become a competitive differentiator for Oracle Cloud.

Oracle's Java IoT offering is comprised of the following platforms and software:

- **Java Standard Edition (Java SE) for Embedded Devices** – This platform is supporting almost 30 different hardware and OS combinations, including embedded-only configurations for ARM and PowerPC. It is increasingly being used in embedded systems, including healthcare gateways, aggregation managers, and patient monitoring systems.
- **Java Platform, Micro Edition (Java ME)** – This platform is used in personal medical equipment, such as glucose management systems. Configurations for Java ME can run on devices with limited memory, processing power, and graphics capabilities, such as mobile devices, as well as on network connected devices that have more memory and processing power, such as home healthcare monitoring devices.
- **Java Platform, Micro Edition (Java ME) Software Development Kit (SDK)** – Provides a development environment for Oracle Java ME Embedded. With the Java ME SDK, embedded developers can write, edit, compile, package, sign, and obfuscate their applications. The applications can then be tested and debugged on Windows or Mac OS X desktops using included device emulators and built-in profiling support. The Java ME SDK also includes the ability to monitor networking and memory usage. [158]
- **Java Card** – The card allows multiple, Java-based applications to run securely on devices with limited footprints (such as a smart meter) that collect and transmit health data in the home. [159]

Oracle's IoT platform can be used for the following devices, acute care devices, imaging devices and solutions imaging devices, invasive and noninvasive patient medical devices, and infusion therapy devices.[160]

Specific information on whether Oracle IoT is offering a hardware solution, software solution or combination of both

As specified above, Oracle offers a combination of both hardware and software solutions.

Company Case Studies

These comprehensive IoT solutions from Oracle are used by healthcare providers around the world. [161]

158. Oracle Java Micro Edition Embedded Client, 2011, Java.

159. Embedded Java Technology Enables End-to-End Healthcare Solutions, 2011, Java.

160. Java and the Internet of Things: The Intelligent Platform for Healthcare, March 2015, Oracle.

161. Cinterion and Oracle: Cellular machine-to-machine communications for a new era of healthcare, Oracle.

Fujifilm

Fujifilm is a full-service diagnostic imaging company with 40 years of expertise in the radiology market. The company developed Fujifilm Synapse Radiology as an integrated family of products that covers all areas of radiology; from radiology information systems (RIS) and picture archiving and communication systems (PACS), to communications, and teleradiology. Oracle Database is embedded in Synapse products, making it possible for Fujifilm Synapse Radiology to provide secure access to RIS, PACS, mammography, and cardiovascular images and data, with a single sign-on from any internet-connected computer. This reduces training costs, ensures rapid acceptance with a consistent web-based interface for all users, and improves diagnostic accuracy with multiple viewing options for patient images and data. "We chose Oracle as the embedded database technology in Fujifilm Synapse PACS because of its robustness, its reliability, and its scalability. Oracle offers five-nines uptime, which is essential for patient care systems in hospitals and trauma centers. It was also the only commercial database capable of running multiple sites from one single instance, supporting enormous volumes of remote users with no loss of performance, and scaling seamlessly as our customers' requirements grow," says Jim Morgan, Executive Director of Marketing, Network Systems, Fujifilm Medical Systems USA. [162]

Cerner Corporation

Cerner Corporation is a leading worldwide supplier of healthcare information technology that offers a comprehensive solution suite that connects consumers, clinicians, and healthcare organizations into a streamlined, unified process. Cerner leveraged Oracle's operational knowledge within a cloud infrastructure to support its mission of eliminating error, variance, and waste for healthcare providers and consumers, and to generate additional revenue. By building on its existing managed service offerings with new cloud based services supported by Oracle, Cerner has been able to reduce capital investments by $9.5 million while also offering its clients a new suite of on-demand infrastructure and software including messaging, storage, and virtual desktop capabilities. Kent Scheuler, Senior Vice President of Managed Services with Cerner remarked that, by using Oracle, "We have been able to eliminate the management and maintenance challenges that would traditionally be associated with introducing a new suite of on-demand infrastructure and software services. This has created a sizable new business opportunity for us, while also allowing our clients to benefit from reduced IT costs and increased performance." [163]

Relative Strength in the Marketplace

Oracle's focus on selling access to applications, or software-as-a-service, and on selling access to tools to program and manage apps as well as analyze data, or platform-as-a-service, added more than 1,600 and 2,000 customers, respectively, in the first quarter of 2016. IDC Health Insights ranked Oracle as the number one vendor for enterprise life sciences software applications, easily topping the list with $60 million

162. Oracle Embedded Technology for the Healthcare Industry, 2010, Oracle.

163. Cerner Selects Oracle Enterprise Manager to Support New Cloud Services, October 31, 2011, Oracle.

more in software license revenue than subsequent vendors. In addition, the majority of top 20 medical device companies run Oracle Applications, and, more than 2,000 life sciences companies use Oracle.[164] For the period ending May 31, 2016 Oracle reported a profit of $2.81 billion, or 66 cents per share, up from $2.76 billion, or 62 cents per share, a year earlier. [165]

MICROSOFT AZURE

Microsoft Azure

Microsoft Corporation, founded in 1993, is a global technology company. Microsoft has developed Azure, a growing collection of integrated cloud services—analytics, computing, database, mobile, networking, storage, and web—for developers, individuals, and businesses. Azure runs on a worldwide network of Microsoft-managed datacenters across 30 regions.

Approach to IoT:

The Azure IoT Suite and Azure IoT Hub have been available since September 2015 and offer integrated tools, pre-built templates, and managed services in order to build and manage enterprise, mobile, web, apps, and connectivity solutions. Azure supports a broad selection of operating systems, programming languages, frameworks, tools, databases, and devices, run Linux containers with Docker integration, build apps with JavaScript, Python, .NET, PHP, Java and Node.js, and build back-ends for iOS, Android, and Windows devices. Communication protocols rely on telemetry, such as sensor readings from a pumping station to a cloud endpoint for storage and processing. Azure IoT Hub is the gateway for connecting devices to the cloud. The service uses AMQP and HTTP protocols for device-to-cloud and cloud-to-device messaging. It comes with a registry to manage the inventory of connected devices. Azure IoT Hub exposes a Service Bus compatible endpoint for smooth integration with backend applications. Existing data platform services such as Event Hubs, Stream Analytics, HDInsight, Azure ML, DocumentDB, SQL Data Lake, and SQL Data Warehouse deliver the processing and analysis capabilities.

The Azure IoT suite offers a broad range of capabilities:[166]

- Collecting data from devices
- Analyzing data streams in-motion
- Storing and query for large data sets
- Visualizing both real-time and historical data
- Integrating with back-office systems

164. Oracle: Committed to the Life Sciences Industry, 2006, Oracle.

165. Oracle Earnings Rise on Growth in Cloud Business, June 16, 2016, The Wall Street Journal.

166. Get more done, Microsoft Azure.

Technical specifications regarding Microsoft Azure IoT Suite IoT products and technology

Azure IoT Suite preconfigured solutions typically use the following services: [167]

- **Azure IoT Hub service** – This service provides the device-to-cloud and cloud-to-device messaging capabilities and acts as the gateway to the cloud and the other key IoT Suite services.
- **Azure Stream Analytics** – This service provides in-motion data analysis, such as processing incoming telemetry, performing aggregation, and detecting events.
- **Azure Storage and Azure DocumentDB** – These preconfigured solutions use blob storage to store telemetry and make it available for analysis. The solutions use DocumentDB to store device metadata and enable the device management capabilities of the solutions.
- **Azure Web Apps and Microsoft Power BI** – Provide the data visualization capabilities. The flexibility of Power BI enables interactive dashboards that use IoT Suite data.
- **Azure Event Hubs** – A scalable publish-subscribe service that can ingest millions of events per second and stream them into multiple applications. This allows processing and analyzing massive amounts of data produced by connected devices and applications.
- **Azure Stream Analytics** – Allows customers to develop and deploy low-cost solutions to gain real-time insights from devices, sensors, infrastructure, and applications. The service can be used for IoT scenarios (e.g., real-time remote management and monitoring; gaining insights from devices like mobile phones and connected cars).
- **Azure Machine Learning** – Designed for applied machine learning.
- **Azure Notification Hubs** – A scalable mobile push notification engine for quickly sending millions of notifications to iOS, Android, Windows, or Kindle devices, working with Apple Push Notification Services, Google Cloud Message, Windows Push Notification Services, Microsoft Push Notification Service, and more.

Specific information on whether Microsoft Azure is offering a hardware solution, software solution or combination of both

Microsoft Azure IoT Suite is offers both hardware and software solutions.

Microsoft Azure's IoT domain

Azure's IoT solution is helping physicians devote more time to treat patients by allowing healthcare systems to maintain a central record of all patient records and real-time monitoring.

Azure IoT covers the following domain:

- **Remote Monitoring Data** – Images, push notifications, and status updates.

167. What is Azure IoT Suite?, Microsoft Azure.

- **Service Data** – Usage data, which includes 400-500 parameters, updated every hour and saved permanently; log files updated every hour; data from real-time location system (RTLS).
- **Patients Records and Monitoring Data** – Built on the Cloud to provide scale to handle up a large amount of users.

Company Case Studies

Azure cloud capabilities serve more than 66 percent of Fortune 500 companies, and offers enterprise-grade service level agreements on services, 24/7 tech support, and round-the-clock service health monitoring. Azure's customers include Skanska, 3M, Dyson, Paul Smith, GE Healthcare, Trek, McKesson, Milliman, and Towers Watson. [168]

Presence Health

Presence Health, a healthcare organization that consists of more than 150 locations in Illinois, with 12 hospitals, 27 long-term care and senior living facilities, and dozens of physician offices and health centers. In order to function more effectively, the organization's physicians and other employees often need to remotely access patient health records. To ensure secure and simple access for these employees, Presence deployed Windows Azure Multi-Factor Authentication. This service helps healthcare workers focus on patient care and makes it possible for the organization to secure access to health records in accordance with U.S. healthcare regulations. "We liked the solution immediately because it is phone-based," says Mike Baran, Presence Health systems director, "Everyone in our organization is tied to their cell phone, so this solution made so much sense to us. Also, this solution was much more cost-effective than the hardware-based solutions we evaluated." Windows Azure Multi-Factor Authentication helps safeguard access to the organization's clinical and financial applications using the phones their employees already carry. Also, remote employees sign in with their username and password, and then use their phone for additional verification. [169]

Wellmark Blue Cross and Blue Shield

Wellmark Blue Cross and Blue Shield, a health insurance company, used Azure to provide custom mobile apps that its members could use to find credentialed healthcare providers and facilities and help them manage their healthcare experience. The company's use of the cloud resulted in a 50 percent decrease in developer effort and time-to-market, low up-front and ongoing costs, scalability, and reliability, while still maintaining desired security and privacy controls. "We found the cloud attractive for two reasons," says Tim Peterson, Wellmark CIO, "The first is that we were already interested in exploring alternative delivery and hosting options to reduce our development cycle time and increase our business agility. And second, with the focus of the project on mobile devices as a way to improve member access to information, it made a lot of sense to put the data in the cloud — as close to those devices as possible." [170]

168. Microsoft 2016 Annual Report, 2016.

169. Presence Health, November 27, 2013, Microsoft Azure.

170. Wellmark Blue Cross and Blue Shield, July 7, 2012, Microsoft Azure.

Great River Medical Center

Great River Medical Center used Azure Microsoft's technologies for the IoT to dispense medications to patients more quickly. It created an automated end-to-end medication management system. By connecting devices and data to back-end systems that manage inventory, medical, and billing records, the hospital eliminated time-consuming manual processes to cut medication delivery time by two-thirds. Great River connected Windows Embedded-based devices, including 2 anesthesia workstations, a pharmacy carousel, and 28 medication-dispensing cabinets, with a central server running Windows and a Microsoft SQL Server database. The result is a reduction in delivery time of patient medication from 1.5 hours to 30 minutes, a $400,000 reduction in inventory costs, a rapid return on investment and ongoing annual savings of $300,000. "The solution from Microsoft and Omnicell automatically prepares the order, then sends it directly to the wholesaler without manual intervention, which reduces the incidence of overstocks, outages, and waste from outdated drugs."[171]

Relative Strength in the Marketplace

Azure IoT represents a promising opportunity. Microsoft is delivering the mobile and cloud services for the IoT, helping customers drive operational efficiency, improve innovation, and create new business models. The Azure expansion strategy included introducing, in March 2016, a series of Azure IoT Starter Kits to help developers test new devices for proof of concept and prototypes.[172] In another move to expand its global IoT business, Microsoft also bought Solair, an Italian IoT company, in May 2016.[173] "The integration of Solair's technology into the Microsoft Azure IoT Suite will continue to enhance our complete IoT offering for the enterprise," said Sam George, partner director for Azure IoT. Microsoft likely will continue to acquire companies in the IoT space. [174]

171. Customer stories, Great River Medical Center, Microsoft.

172. Microsoft Azure IoT Starter Kits, Microsoft Azure.

173. Microsoft acquires Solair to help customers harness the power of the Internet of Things, March 3, 2016, Microsoft.

174. Microsoft Buys Solair for Azure IoT, May 9, 2016, Ecommerce Times.

SAMSUNG ARTIK

Samsung is a South Korean multinational conglomerate company headquartered in Seoul, Korea. It comprises numerous subsidiaries and affiliated businesses, most of them united under the Samsung brand. Samsung is focusing on IoT through several avenues. It recently announced its vision for 'Human-Centered IoT,' including a strategy to spend $1.2 billion over 4 years for U.S.-based Internet of Things (IoT) R&D and investments.

Approach to IoT:

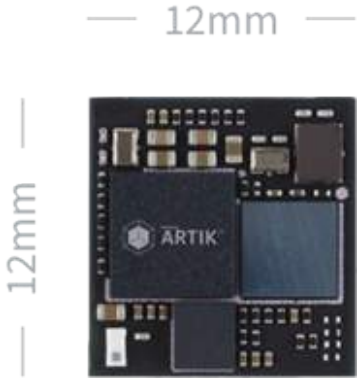
More hospitals and health networks are engaging in home monitoring and patient engagement strategies to monitor and analyze patient data valuable to providers. To respond to this, Samsung ARTIKTM announced an open platform comprised of hardware modules, software, and cloud services for connecting objects via Wi-Fi, Bluetooth, and ZigBee.

The company offers three hardware modules that device-makers can use to create IoT products:[175]

- **ARTIK 1** – A tiny module with a 9-axis motion sensor for low-end mobile devices such as beacons, activity bands, and fitness trackers.
- **ARTIK 5** – A slightly larger module for smart home hubs, high-end smart watches, drones, and IP cameras.
- **ARTIK 10** – A module for devices that require high-performance processing such as home servers, smartphones, and media hubs.

Technical specifications regarding ARTIK IoT products and technology

The ARTIK family of devices is supported by a software stack that obviates the need to write low-level drivers for devices. Samsung's ARTIK modules are Arduino-certified, meaning they can be programmed using the Arduino integrated development environment. They also come with Samsung's Secure Element, a cryptographic hardware security mechanism designed to prevent unauthorized access. The ARTIK platform includes three levels of modules, all of which boast Bluetooth and cloud connectivity and can support Android and iOS operating systems.



175. IoT moving into home healthcare, May 14, 2015.

The ARTIK 1, with its small size (12 mm x 12 mm), is aimed especially at power-sensitive devices, and provides excellent performance in a portable environment. The ARTIK 1 Module is a highly integrated combination module for the IoT that utilizes dual MIPS© processors, embedded memories, and power management. In addition, the module is packaged with flash memory, a crypto engine, and communication using Bluetooth V4.1.[176]

The ARTIK 5 uses Samsung's next-generation ePoP (package-on-package) technology to offer a broad cross-section of devices and applications with the best combination of computing power and storage capacity at its size. ARTIK 5 offers a balance between performance and power consumption in a 30 x 25 mm footprint. The many standard digital control interfaces support external sensors and higher performance peripherals to expand the module capabilities. With the combination of Wi-Fi and ZigBee, the ARTIK 5 is the perfect choice for home automation and home hub devices, while also supporting a rich UI/UX capability with the camera and display options. The hardware based Secure Element works with the ARM® TrustZone® and Trustonic's Trusted Execution Environment (TEE) to provide "bank level" security end-to-end.[177]

The ARTIK 10 is ideal for applications with higher local performance and storage requirements, or demanding video encoding and playback needs. ARTIK 10 integrates rich wireless connectivity with built-in advanced security capabilities, leveraging the same high-volume, high-performance processor and semiconductor expertise found in Samsung's flagship mobile phones. ARTIK 10 delivers the kind of performance and integration that, up until now, has not been available in the diverse IoT market. Samsung's ARTIK™ 10 Module is the world's highest performance IoT module, inside a package that is just 29 mm x 39 mm x 1.3 mm. The scalable processing power of the ARTIK 10 makes it ideally suited for video and image processing tasks like autonomous vehicle navigation, intensive 3-D graphics, or large immersive displays. Alternatively, the small size of the ARTIK 10 enables servicing application domains with a high local computation requirement, like model-based robotic control, virtual reality, or image processing.

176. Samsung Artik Modules – 020 Product Brief, 2016, Samsung.

177. Samsung Artik 10 Product Brief, Samsung.

The Samsung ARTIK Cloud was announced in April 2016. Samsung ARTIK Cloud is an open data exchange platform that provides easy-to-use, open APIs and tools to securely collect, store, and act on any data from any connected device or cloud service. Using these APIs and tools, IoT solutions and services can be brought to market. The ARTIK Cloud is already commercially available with a tiered pricing model. The ARTIK Cloud, along with the ARTIK family of highly integrated IoT modules, enables faster and simpler development of new enterprise, industrial, and consumer applications.[178]

Specific information on whether ARTIK is offering a hardware solution, software solution or combination of both

The ARTIK modules and ARTIK Cloud make up an open platform that includes a family of integrated production-ready modules, advanced software, development boards, drivers, tools, security features, and the ability to connect these devices and services to the cloud.

ARTIK's IoT domain and Customer Information

Samsung ARTIK modules are offered in a range of sizes, from the ARTIK 1, ideal for wearable devices, low power consumption, and Bluetooth low energy support, to the ARTIK 10 for multi-device monitoring stations. The ARTIK Cloud enables the communication, aggregation, and data analysis of wearables and health devices. If the platform works as advertised, developers new to the IoT will have an easier time taking a concept and forming it into a shippable product, whether that product is aimed at home consumers or solving social challenges.

Company Case Studies

Samsung ARTIK will enable the communication, aggregation, and data analysis of wearables and health devices, empowering users and enterprises to monitor their health in order to improve it. ARTIK promises to help with many of the challenges developers face daily, such as non-standardized data collection across device vendors, enabling communication between diverse devices, and keeping data safe. While there aren't many examples available at this point, startup Reflx Labs appears to be one of the frontrunners showing the advantages of ARTIK chips. [179]

Reflx is the startups behind the Boogio bionic foot sensor, a paper-thin shoe insert with thousands of layers of pressure sensitivity, containing an accelerometer, gyroscope, and Bluetooth connectivity. The team is working with Florida Hospital to develop new rehab solutions for pediatric patients. A system like Boogio could allow the development of interactive and engaging treatments not only for children, but for adults and athletes as well. One of the challenges facing Reflx was the miniaturization of the system, which according to Jose Torres, Reflx Labs CEO, was possible only thanks to Samsung's ARTIK 1 miniature system-on-a-chip.[180]

178. Announcing Samsung ARTIK Cloud, Samsung Artik.

179. Seattle startup will use Samsung's new Artik chips to turn ordinary sneakers into smart shoes, May 12, 2015, Geekwire.

180. Samsung introduces Artik: An all-new Internet of Things development platform, May 12, 2015, Tech Hive.

Relative Strength in the Marketplace

Samsung sees huge opportunity in IoT solutions, and its ARTIK initiative has the potential to accelerate the development of IoT solutions for problems around the world. Samsung is aiming to cover the full spectrum of IoT development with its of ARTIK devices. [180]

Samsung's CEO, BK Yoon, pledged $100 million in the development of the IoT platform at the beginning of 2016 and plans to equip 90 percent of Samsung's devices with IoT capabilities by 2017. Overall, the IoT market is expected to nearly triple to $1.7 trillion by 2020, with modules and sensors representing over 30 percent of the total market. [181]

MAIN PLAYERS

Key Innovators:

181. IoT, Semiconductors Among Three Key Drivers For Samsung, November 9, 2015, Forbes.

APPLICATIONS:

CYBER SECURITY CONCERNS

We have seen the application of the IoT in various sectors like public transportation, retail, universities, business, manufacturing, industrial automation, residential, and others. The type of devices and networking equipment used to run the IoT are usually designed with low power consumption and low power CPU, meaning they can be easily implemented anywhere.

Since many devices talk to each other, connect to the cloud, and operate in a networking environment, any security breach could result in huge loss. Many large companies have conducted research on possible cyber threats to IoT devices and found surprising results. AT&T's Cybersecurity Insights Report found that hackers can expose security loopholes in IoT devices, including connected cars and wearable devices.[182] The result of the report helps us understand how to prevent security breaches and devise plans that can help companies to diagnose potential gaps in security and take appropriate action.[183]

Below is a summary of security vulnerabilities in IoT, which was made from analyzing results of security analysis conducted by large technology and cyber security giants including HP, Cisco, Symantec, and IBM.[183]

INSECURE WEB INTERFACE

Many IoT devices have web interfaces and research shows that they can be easily exposed to security breaches, such as persistent cross-site scripting, weak default passwords, and weak session management. In an example of persistent cross-site scripting, an attacker stores malware or JavaScript code on their server. They use this when a user returns to a web page they've been to before, the page displays normally, but the attacker can display a pop up message or dialog box that they want the user to click. This enables the attacker to gain access to the user's computer and information. The attacker may target this type of attack on a website that does not support HTML tag filtering. Weak default passwords allow hackers to easily guess passwords. Verizon's 2016 Data Breach Investigations Report (DRIB) found that weak, default, or stolen passwords are responsible for 63 percent of data breaches.[184] HP's research also shows that devices accessed via the cloud enable hackers to determine valid user accounts using the password reset feature.[185]

Security issues in software and firmware

We know that software runs on a device, which connects to the Internet and downloads critical updates. HP's research shows that there is no encryption during downloading of a software update. Moreover, the update files are not securely protected, can be easily intercepted, and, as a result, poses a greater security risk for IoT devices.

182. The CEO's Guide toCyberbreach Response, AT&T Cybersecurity Insights.

183. Internet of things research study, 2015, Hewlett Packard Enterprise.

184. 63% of data breaches involve weak, default or stolen passwords, May 4, 2016, IT Governance.

185. Cybersecurity and the Internet of Things, March 2015, EY.

Authentication and Authorization

If a device doesn't have a strong password mechanism, it allows attackers to expose security loopholes like a weak password or weak password storage mechanism and attackers can gain complete access to the device. Research further shows that most devices allow users to store simple passwords, and as a result, devices can be easily hacked.

According to recent Symantec report, IoT devices, which are in constant communication with the Internet or the cloud, may be vulnerable to cyber attack. Attackers try Man in the Middle (MITM) attacks by trying Address Resolution Protocol (ARP) poisoning or modifying domain name systems and can try to redirect traffic. Some devices do not verify the authenticity of the certificate if it is performed over HTTPS connection or do not take part in mutual SSL authentication and ignore the certificate revocation list. Attackers can obtain the key and can easily carry out cyber attacks.

Some devices use direct connection to communicate with back-end services. In most cases, devices use unencrypted network communications. The number of unencrypted connections is greater in case of local area connections. Attackers can easily intercept personal data and login credentials since they are transferred in plain text format.

Lack of Encryption

Most devices consume and transfer data via the Internet and the cloud. Failure to encrypt sensitive data means that information can be easily intercepted as it travels through the network. Encryption mechanisms need to be implemented to prevent data from being intercepted.

Privacy Concerns

Research shows that privacy is also a concern as most devices store personal information, such as name, address, cell phone number, credit card information, and these devices connect to the cloud and the Internet. In the case of a security breach, hackers can easily get access to valuable personal data and can share that information with the rest of the world.

Security Loopholes

Ernst & Young research has found many security loopholes.[185] Employers frequently use their mobile devices to access work-related data and as a result, the company faces security risks. If a mobile phone was infected with malicious apps, it could expose security vulnerabilities. If an app developed by the company contained any security weakness, hackers could expose it and they would have access to potentially valuable information. The increasing number of mobile devices also creates more problems as the vulnerabilities associated with them spreads rapidly. Cyber criminals will take advantage and are likely to sell hardware equipped with malware or malicious code that can be turned into a botnet, which can be used to perform DDOS attacks by using those devices.

Vulnerabilities with physical access to IoT devices

Symantec research shows that when someone gets physical access to a device, they can expose security vulnerabilities. They can change the configuration of a device, gaining the ability to inject malicious code or malware on the network. Attackers can issue a new device-pairing request, configure a new password by resetting the device to factory settings, or install custom SSL certificates, and redirecting traffic to their server. Physical access allows attackers to read the device's internal memory and firmware. In addition, attackers can get access to information like cryptographic key materials, design flaws by reading internal memory, and reversing the firmware. Attackers can also upload malicious firmware and take full control of the device. Devices get firmware updates through a USB connection, over the network, or an SD card, and in most occasions, firmware updates are not digitally signed or encrypted, which allows attackers to inject malicious firmware into the update.

Some people like to buy second-hand devices to save money. If the second-hand device is equipped with malware or malicious code, hackers can use it to take complete control of the device. In case of a supply chain attack, Symantec has found that hackers can easily take control of the network and infect software updates with malware and infect the devices with malware.

Vulnerabilities with remote operation

Devices have web-based GUI or API that users can use to send commands. Remote operation of these devices is also supported. Symantec has found that these interfaces suffer from known vulnerabilities like cross-site scripting, broken authentication, cross-site request forgery, command injection, buffer overflow, and others.

Many cloud services do not log users after a number of failed login-attempts and many do not implement 2-factor authentication. In addition, many devices have weak password recovery methods and reveal private information during the recovery process and so it becomes easy for attackers to perform account harvesting.

Symantec tested devices and reported vulnerabilities like cross-site scripting, path traversal, remote code execution, and SQL injection, among others. These are serious and well-known vulnerabilities and can affect the entire industry if any of these vulnerabilities are exposed. Symantec research also found that malware can be injected in IoT devices, and if it is undetected for a long period of time, can easily infect other IoT devices.

Open-source vulnerabilities

IBM has conducted research on cyber security and found the following problems. Many companies want to expedite their development process and are interested to turn to open source products, since they can reuse existing implementations to expedite their development process. But open source software may have known security vulnerabilities, such as Heartbleed/OpenSSL, which are documented, and it becomes easy for hackers to target IoT devices.

IoT device manufacturers as point-of-attack

IBM has found that IoT devices can be physically removed and then reverse engineered by an attacker. If the manufacturer systems become infected, IoT devices will be infected or compromised due to the infected manufacturing process. If we use the devices equipped with malware, hackers can take advantage and inflict serious damage.

CYBERCRIME PREVENTION

Many companies have done research, have suggested techniques, and designed security guidelines so companies can prevent cyber crime.

Ernst & Young have suggested that companies should be more active and counter cyber attacks in a collaborative manner, their suggested the state of readiness includes the following:

- Designing and implementing a cyber threat intelligence strategy to support strategic business decisions and leverage the value of security
- Defining and encompassing the organizations' extended cyber security ecosystem, including partners, suppliers, services, and business networks
- Taking a cyber economic approach — understanding your vital assets and their value, and investing specifically in their protection
- Using forensic data analytics and cyber threat intelligence to analyze and anticipate where the likely threats are coming from and when, increasing your readiness
- Ensuring that everyone in the organization understands the need for strong governance, user controls, and accountability

Since cyber attacks can happen any time, it's good practice to detect and respond quickly. Ernst & Young suggest establishing a Security Operations Center that performs this function. A Security Operations Center can become an effective part of an organization by correlating information, generating reports, making better decisions, and handling risky activities.

Ernst & Young have suggested that companies need to take appropriate security measures and perform regular testing on networks and IoT devices. They have suggested the following:

- A complete and thorough understating of security and types of cyber attacks that can occur is required to build good cyber security measures.
- Organizations need to learn continuously and evolve their cyber security capabilities. Since attackers look for new strategies to find security loopholes in a network, it is better to study data, build relationships, and redefine security guidelines continuously.
- Organizations need to enhance their incident response and crisis response mechanisms. If a company possesses effective incident response capabilities, it will help it to act effectively during any incident or cyber attack.
- Companies must align cyber security to business objectives. Organizations must receive the necessary financial and leadership support so that they can provide better protection, build good relationships with other companies, and raise awareness among employees.

IBM has suggested that companies apply different techniques to effectively counter cyber attacks. These include logging analysis technique to identify and respond to anomalies. In order to prevent potential security breaches, companies should monitor system behavior, detect situations where anomalies have been detected and react to those situations. This type of situation can occur when a device is infected with malicious code; attackers carry out denial of service attack, or persistent attack on the device that is part of

the whole network. Companies can respond to this situation by monitoring the usage pattern of the system. Companies can use tools like IBM Security QRadar® SIEM (Security Information and Event Management), to monitor pattern and detect anomalies among rogue devices.[186]

Devices must be constantly monitored to understand common usage patterns so that organizations can quickly identify rogue devices, which may emit usage information that is inconsistent with normal usage patterns. Tools like IBM Operations™ Analytics - Log Analysis, can be helpful since they enable companies to identify devices that are acting outside of the expected usage pattern. [187]

IBM suggests that companies must have active audit processes that enable companies to foil any attempt of inside attacks. Companies should maintain log records for a long period of time so that forensics can gain better understanding of the nature of cyber attack if a security breach occurs.

Companies should maintain a secure environment to counter cyber attack. Companies must provide the necessary support for authentication, authorization, auditing, and administration of IoT devices. In addition, companies must manage keys and storage so that data can flow in a secure manner from source to destination.

Companies should make sure devices, gateways, and routers are updated regularly so hackers can't expose security vulnerabilities. Since the number of devices increase over time, it isn't feasible for a company to maintain the operational cost. So, companies can remove the device from the network and configure gateways to ignore information coming from that device. Moreover, manufacturers can produce devices that operate in fail-safe manner so that devices no longer need to connect over the network. In this way, attackers would not be able to take control of the device.

Companies should possess an incident response process for handling security related incidents. When an incident is discovered, the process should have a remediation plan that can respond and and close the vulnerability. In order to reduce the effect of the attack, the process must inform other component owners so that they can execute a remediation plan as needed.

Network giant Cisco has also come up with an innovative solution to prevent cyber crimes. According to Cisco, the IoT is growing fast and it is expected to grow from more than 12 billion devices in 2015 to 50 billion devices by 2050. As the number of devices grows, the complexity of securing the network gradually increases. Companies face the following challenges:

Scale

Companies' IoT solutions need to scale to hundreds of devices and they need to find cost-effective solutions.

Remote Locations

Companies sometimes install IoT devices in remote locations. These devices must withstand extreme

186. IBM Security QRadar SIEM, IBM.

187. IBM Operations Analytics - Log Analysis, IBM.

conditions like rain, humidity, and high or temperatures, and, often, must fit in small spaces. Moreover, these devices should support remote maintenance and support features so that field visits by technician are not required.

Availability

Some companies don't like to shut down their devices, since they think the cost of downtime can exceed the cost of remediation.

Cisco suggests that the comprehensive IoT solutions need to do the following:

- Provide visibility into applications, users, protocols, and anomalies.
- Allow critical systems to continue operating even when under attack.
- Simplify compliance with industry or government regulations.
- Scale cost-effectively to accommodate more IoT devices or more data.
- Increase situational awareness and accelerate incident response. Situational awareness requires a combination of video surveillance, identification of people and devices, and collection and analysis of telemetry and logs.
- Integrate IT and OT processes. Connecting OT systems to the IT network increases the value of your existing IT security investments and policies.

Cisco offers a wide range of solutions that can prevent cyber attack. Cisco's network solution can detect network anomalies. It has the following features:

- It can enhance VPN performance by using hardware acceleration.
- It can detect and resolve distributed denial-of-service and other types of attacks.
- It can prevent misconfigurations so that attackers cannot expose and exploit them.
- Prove support for access control depending on device type.
- By using Cisco Identity Services Engine, access to IoT devices can be controlled based on user and device identity.
- It enforces policies.

Industrial networks usually require advanced protection needs and Cisco offers a wide range of network solutions that help industries to ensure safe service delivery. Companies can deploy Industrial Security Appliance 3000 to achieve the following: [188]

- Take advantage of proven threat management from Cisco ASA with FirePOWER™ Services.
- Support OT protocols and applications.
- Detect and protect against OT specific threats including DDoS, operational safety, and insider attacks.
- Gain visibility into the protocols, devices, and applications.
- Secure Internet connectivity with high-performance VPN, Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP), and Network Address Translation (NAT).

Cisco solutions also support features like detecting activity near an IoT device. Cisco's IP camera comes

188. Cisco 3000 Series Industrial Security Appliances (ISA), Cisco.

with wide dynamic range technology and is capable of producing images even when illumination varies in the same scene. Cisco solutions also include physical sensors and IoT sensors for motion detection. In addition, Cisco's fog nodes can be deployed anywhere and it enhances the support for cloud by being close to the devices that produce IoT data.

Symantec Corporation has suggested that the users can follow the following guidelines to prevent cyber attacks.

- Strong passwords need to be used in IoT devices and Wi-Fi networks. Attackers can guess easy passwords and are able to expose security vulnerabilities
- We should not rely on the default password that is stored on many IoT devices. Attackers can easily target devices with default password and conduct cyber crime.
- We must use strong encryption methods when setting up Wi-Fi networks like WPA2
- Wireless connection is found to be more vulnerable than wired connection. We should use wired connection instead of wireless where possible.
- We should not purchase secondhand IoT devices from the market since those devices may be infected with malicious code.
- We should conduct research on vendor's device security measures and try to find any security loopholes if exits. We should modify the privacy and security settings according to our business needs.
- We should always update our IoT and networking equipment and disables features which are not required.
- Devices should be installed on a separate home network.
- We must make sure that the network remains stable when a power outage or maintenance operation is performed.
- Remote access to the devices should always be protected. If attackers are able to take control of the device, they can shut down the entire network.
- We can turn off smart features if normal features are sufficient to serve our purpose.
- Symantec has advised smart home device manufacturers to follow the following security guideline to produce secured device.
- Devices should be programmed to use proper encryption mechanism like SSL/TLS encryption when they communicate over the network
- Devices should check the SSL certificate and the certificate revocation list before it carry out any operation
- Device should check for easy password and make sure users choose password of sufficient complexity.
- Device should enable the user to change default password and never store any hard-coded password.
- Device should have the capability of receiving update over a connection
- Device should have the capability to work without network connection.
- Device should logout after multiple failed login attempts
- Device should have a secured web interface and API

  Device should operate in a fail-safe mode when power outage occur

- Users should be able to lock devices to prevent any cyber attack
- Device should have features like secure boot chain, security analytics, etc.

MARKET SIZE FOR CYBER SECURITY

Since the number of cyber attacks is increasing rapidly, companies are investing money to prevent cyber threats. The cyber security market is growing rapidly as companies are interested to secure their IoT devices and network. Markets and Markets has done research in this area and has estimated that cyber security market will grow to $202 billion by 2021. [189]

A BI Intelligence report shows that $655 billion will be invested to protect PC, mobile devices, and IoT devices between 2015 and 2020.[190]

Since the rates of cyber attack are increasing rapidly, companies are investing in different areas to secure their environment. IDC has forecasted that areas like security analytics, threat intelligence, mobile security, and cloud security will grow as companies are likely to spend in these areas. A recent report from Transparency Market Research shows that cloud security market is likely to be worth $12 billion by 2020. [191]

CONCLUSION

Cyber threats have become a concern for most industries. Cisco predicts that the number of IoT devices is increasing at an alarming rate and so the task of securing IoT networks has become increasingly difficult. Companies must invest money in securing IoT devices and the surrounding environment. Top companies should give it a higher priority and must adhere to standard security guidelines and work with IT professionals to build a secure working environment.

189. Cyber Security Market worth 202.36 Billion USD by 2021, Markets and Markets.

190. This one chart explains why cybersecurity is so important, April 5, 2016, Business Insider.

191. Cloud security market to be worth $12 billion by 2022, here's why, January 14, 2016, Tech Republic.

INDUSTRY PARTNERS INSIGHTS

In order to gain a real world perspective on the IoT in different areas, we interviewed industry experts. We interviewed Linden Tibbets, CEO of IFTTT, Alok Tayi, CEO of Tetrascience, and Bill Shingleton, Technical Lead at GE Healthcare. We asked them questions to get their perspective on the IoT, where they think it's headed, and any roadblocks they envision along the way.

Interview with **Linden Tibbets**, CEO of IFTTT

Linden Tibetts: So, a quick background, we launched the company in the end of the year in 2010. We've grown a great deal since then. The initial vision was actually one that was conceived during my time working at the design from IDEO. We saw this big opportunity in how the world thought about software.

Since the beginning of software development, it has been thought of in a very siloed way — and that's not necessarily a bad thing. What I mean by silo, is any piece of software or any application has data stored somewhere either on the Cloud or on a device, has some type of application logic and it has some type of interface, a way for a human to interact with it, it could be an app, could be a website, could be a desktop application.
And what's happening now is that as consumers or people within the enterprise begin to surround themselves with more and more of these ever-more specific applications, Netflix, BMW has a connected car, your Samsung TV is connected to the Internet, your Facebook account, your Gmail account, your calendar, and so on and so forth.

Each one of those services has locked away information about who you are, your preferences, how you use that tool, the ways in which you use that tool. But it also has capabilities. Things that it can do on your behalf, your calendar can create a new event, your BMW can unlock and lock the door, your Samsung TV can turn on and off, so on., What's really interesting is there's incredible power locked away from one service to the next, if you think about that information, those capabilities and what this is all about is really helping individual services and the people that use them unlock that power by being able to reach across those server silos, from one to another and ask for permission and access that information and those capabilities and then normalize them in a standardized way.

How that works, on the consumer side, we have this idea of Applets, this idea of end users creating simple connections between these silos, it's this and that. It's how they work. For example, if it's going to rain tomorrow, then send me a text message in the evening to let me know, to get my rain gear ready or if the San Francisco Giants game starts, then turn my lights orange. If someone rings my connected doorbell, then turn on the porch light and save the picture of that person in the drop box, so on and so forth.

We're able to make these simple connections, these simple kinds of cuts from one silo to the next. And what that's really led to is tremendous interest, we run about a billion applets every month

We're moving massive amounts of information back and forth between services. Our users have created over 40 million Applets, and that's gotten a lot of attention on the developer side, or what we call, partners. We have a partner platform that's been in private Beta for the better part of a year now, it allows partners to essentially plug in to register their service, their silo, but also over time to be able to build on top, to actually be able to build connections between silos for themselves.

Let's say if BMW wants to access ADP's alarm system, to know when the alarm goes off, whether to arm or disarm your alarm if you get home or leave. If they can get that access, they can access that permission in a way that the user understands and is familiar with.

We think what the Internet of Things represents is this tremendous opportunity, it's even more software silos. And then, what this is all about is helping people connect those silos, whether you're an enterprise, whether you're a developer, or whether you're an end user.

PreScouter: ***Thanks for that explanation and for going through those various examples of how IFTTT is really creating additional value. So, how is your company tackling the IoT challenge? From what you've told me and with all of the various applications that you've mentioned throughout various industries, is it accurate to say that your company is also focusing outside of the residential sector into other types of applications in industry?***

Linden Tibetts: Yes, it's an important thing to understand about what we do to recognize that for every connected device, there's a device connected to the Internet regardless of what that device is, a sensor, a doorbell, car, a giant piece of machinery on a factory floor.

What that actually represents, is another service, another API. It has information; it has capability, inputs, and outputs. And what this is about is connecting those inputs and outputs together, allowing people to

essentially program those inputs and outputs; to control their reality in any way that someone would be possible or valuable.

And so, for IFTTT, the connection to devices, the IoT part of it is really just a piece of that story. We're just as excited about whether it could be Facebook or Dropbox or Salesforce or Slack or Skype as we are about Nest or your Dropcam or your ring connected doorbell, or your connected BMW, so on and so forth.

Each one of those actual devices, even though I think we're likely at steps with the physical device itself, once it connects to the Internet, it's really no different than Facebook, or Gmail. And that's the way we view the world. Everything, the service, every noun that you could possibly point to, whether that's an organization, whether that's a business, a person, place, thing, all of those things, as they connect to the Internet are going to be services, and they're going to be compatible with IFTTT.

So, we view the world incredibly broadly. Our focus now is on the consumer space, and we've gotten a lot of headway with residential IoT and other services as well. But our plans are universal, everything, the service. And we want all of those services to work with it.

PreScouter: ***What changes do you think IoT will bring to your industry? I'd be particularly interested in your take on the evolution that you've seen during these past years that you've been running IFTTT, as well as the changes that you think will become more pronounced in the future.***

Linden Tibetts: I think one of the biggest challenges is the explosion of new services, more data, more accounts, more problems, more air, more surface area for security breaches or attacks. And then, I think whether that's the enterprise or whether that's someone connecting devices in their home, there's a tremendous opportunity to make things easier — to simplify.

I think the biggest thing IoT brings is more of everything, more of the Internet. And, I think with that, all the problems and opportunities to solve those problems with that entails.

PreScouter: ***What is your quantitative estimate for the impact today and in the future of IoT devices?***

Linden Tibetts: I think it's an opportunity that's both different, and similar in size to the smart phone. It's not going to be an all at once, the iPhones launched and we're in this new world. But it's something that over time, as each one of these individual things begins to add up, and we begin to drive new insights and

contexts from the data that all of these new connecting devices bring to the enterprise or to the individual, it's going to be just as revolutionary.

So, you could argue that things like drones are IoT as much as anything. Just because the thing flies, it's connected to the Internet and it's a service. So, I think if you look at the broad view for what IoT is, its economic impact, and business opportunities just as big as the shift from desktop to mobile.

PreScouter: ***What does IFTTT wish to accomplish within the IoT space in the next five to ten years?***

Linden Tibetts: We want to grow and increase the value that we bring to end users and our developer partners, and we want to become the brand that stands for confidence in compatibility.
When a partner or end user is making the decision about a new service, whether that's an IoT device service or something totally different, they look to make sure that that service works with IFTTT because it stands for confidence in that service being compatible with, and working well with, all the other services that someone has surrounded themselves with so far.

PreScouter: ***Are there any players or trends you'd like to highlight providing novel offerings in the IoT space that you think people should be aware of?***

Linden Tibetts: I think one of the things that's been interesting to see take off is how clearly it is to communicate the value around products that bring peace of mind.

Whether those products are security-based in nature, Nest Cam, a Ring as a connected doorbell that allows people ringing your doorbell, it's essentially that digital replacement for the people. You don't have to get up there to look through the door. Or these other products, like great product called Awair that is about air quality in the home; humidity, organic compounds, things related to the breathability of the air in your house.

In any of those products, I think the value part is very, very clear. People want to make sure that their homes are livable, are secure, are safe, and anything that touches that has just been far and away kind of an early winter with regards to the consumer and connected devices within the home.

PreScouter: ***Going back to IFTTT, which sort of IoT offerings within your platform are you most excited about bringing on to the market, any new developments that you think will increase that value that you bring, that you are excited about offering?***

Linden Tibetts: I think the early versions of the assistants that all the large tech companies are working on Bots, Amazon Alexa, Google Home, Siri, and Microsoft Cortana. I think all of these assistants are incredible ways to interface with the connected devices within your home.

And it's still very, very early days. What's so interesting about what gets lost so often with these assistants is that for them to be useful or as useful as we think they can be, they need access both to the information that's locked away in those silos, and the capability.

Alexa needs the ability to unlock and lock your door, or turn on and off the lights, or understand how many people are in your home, and is your dog outside or inside, so on and so forth. What IFTTT is building is effectively the platform for Alexa and any other systems to gain that access. AI without access is kind of like Einstein locked in a closet.

PreScouter: ***Are you saying you'll be helping these kinds of assistants by providing access to that data and that's one offering your company is working on?***

Linden Tibetts: Yes, that's correct.

PreScouter: ***Could you describe what you envision being the biggest challenges to making the transition to IoT? We've already seen quite a large shift in this direction but are there any sort of barriers that will make this transition difficult?***

Linden Tibetts: I think the important thing to think about the IoT is our traditional view of administering and managing our software tools is no longer applicable. We think about the world of software as being really relegated to just a handful of devices, our laptops, our phones, and maybe a couple of other things.

With IoT, that then kind of explodes outwards at an exponential rate. Individuals and enterprises are going to have to manage all kinds of other devices connected to the Internet. So, the surface area is that expands the problems change dramatically. I think even though we've already been through this a little bit as we went from everybody having a desktop computer, and now also having a phone, this is very different.

It's not just 1 to 2; it's 2 to 200, 2000. I think that is the biggest problem.

PreScouter: ***That's a great insight. What do you think the biggest risk that will come with this greater adoption of IoT will be? A lot of people are already worried because of cyber security issues, can you comment on that or any other risks that you see with that?***

Linden Tibetts: I think the real risk is being too obsessed over the devices themselves.

It's really that the value that comes with the Internet of Things has very little to do with the hardware or the devices themselves. It has everything to do with the software and our ability to communicate that value either through the data or the capabilities that it brings to the individual or the enterprise.

PreScouter: ***How long has your company has been involved in this space?***

Linden Tibetts: Since the very get go, we were. I believe we launched at the end of 2010 and we had our first connected device, might been early 2012.

So, it's been four or five years depending on how you're counting. But, we knew that the Internet of Things was going to be a major application of our technology, but we've also been very surprised at how quickly that has arrived. I think we're still just at the very early onset of what it means to connect every noun in the world to the Internet.

PreScouter: ***Which wide-area networks do you envision your technology leveraging and how does this idea scale with demand?***

Linden Tibetts: For us, we're very unique; we are agnostic. All we care about is once something connects to the Internet, once it connects to the Cloud, it can work with IFTTT.

How these devices communicate between each other, how these devices actually go from just being a "dumb" device to actually connect to the Internet, probably doesn't matter. We're confident that once it connects to the Internet, that's where all the value happens. So, I think a lot of the talk around what's direct communication protocol is important but really misses the point.

For something to truly add value, it's going to have to connect in a centralized way to the Cloud.

PreScouter: ***In terms of your experience with all of your different users and developers, have you seen a trend moving from one particular network or emerging? We've seen for example, a lot of these types of devices leveraging ZigBee within the residential space, any comments to that? Have you seen any of those trends?***

Linden Tibetts: No, I think at some point everything will be on Wi-Fi. At some point, everything will connect to your centralized router and that router will step up to the Internet.

PreScouter: ***How does Big Data and machine learning pair with your technology?***

Linden Tibetts: It's incredibly important. We leverage machine learning for all types of things, the Internet of Things means more data, more capabilities, and we need the tools developed around the Bid Data and machine learning to make sense of it. To provide insights both to individual consumers and to the services and enterprises themselves.

PreScouter: ***What is one factor that would accelerate adoption of your IoT technology or platform among users?***

Linden Tibetts: I think a number of things: price, relative to the value or which the value has been communicated; ease of use, simplicity in terms of how you connect something to the Internet; how you manage that connection over time; how manage your account and the multiple accounts across, whether it's your family or everybody you work with.

I think those are going to be major barriers that begin to lower over the course of the next couple of years.

PreScouter: ***Shifting now to toward government, what role do you think that government should play within the IoT space, if any?***

Linden Tibetts: I think there's definitely a role for the government to play. But I think just like the government has approached other emerging technologies, they need to be very careful about how quickly they look to impose standards or regulations on something that's still being figured out. I think there's certainly a role to play, but it's one where I would advise everyone in the industry and in government to be wary about getting too far ahead of an emerging technology.

PreScouter: ***If you could convey one core concept of IoT to the C-suite across your customer base, what would it be?***

Linden Tibetts: Services, everything is a service. We should stop obsessing over the devices, and start thinking about how do those devices connect to the Internet and start to create new data, new information and allow those capabilities within that device to be exposed and accessible to other services, that's where the magic happens.

Software and services, the devices themselves, I think, over time will largely be the sideshow to the services, and the power of the software and what you can do with that software. It's going to be where all the magic happens.

PreScouter: ***How does the information being created through your IoT technology create value?***

Linden Tibetts: As devices connect and create new services, new information, and the big new piece of value is an increased understanding of context.

You think about what happened with the smartphone and all the sensors that it had, you were able to do things around location, you were able understand things about family, location but, were you walking, were you in a car? You are able to have a constant connection to a person and that person then had all kinds of new tools at their disposal.

What all those sensors and these constant connections, and the proximity, the fact that it was something you could put it in your pocket, really unlocked were all new types of use cases, new types of services, new types of businesses. And I think the IoT is similar in that regard.

As it begins to provide more information about context, more sensors, more data, more capabilities, and, not just the people, but also the things. I think there will be entirely new services that we wouldn't be able to envision that will come about.

PreScouter: ***What are your thoughts around the IoT adage, your information is only as good as your sensors?***

Linden Tibetts: I think that seems reasonable to me. If your sensor doesn't work, you can't get good information. But I would also say, your information is only as good as what you're actually able to do with it.

I've got tons of information; do I use it all always? No. Other people probably use a fraction of a percent of the information that they actually have access to or that they store. I think the same goes for the enterprises, so it's really about how do you help the enterprises and the individuals go from making use of 0.01 percent of the information available to them to 2 or 3 percent? And that's a dramatic jump in value if you can unlock usage around that information.

PreScouter: ***What is the craziest idea that you've heard around IoT?***

Linden Tibetts: That's a good question. I think there are no crazy ideas. I think, often times, you see the public kind of crying foul about the next silly thing connected to the Internet. Your toaster, your juicer, and so on and so forth. I think what's really interesting about that is that those are crazy now but if you look at things like the price, or the hassle involved, or the value you actually get, relative to that price and hassle.

But over time, I think it's really hard for us to put ourselves in this world where connectivity is as ubiquitous as electricity, and I think there really are no crazy ideas if we think about it over a really long period of time, especially related to connectivity. All these things are going to be connected and it's really a matter of thinking, at what point does the hassle and the price, drop below or on par with the value you actually get from us being connected?

PreScouter: ***Great, and final question, is there anything at all that we haven't talked about today, that you think would be of interest, that you would like to highlight to our readers?***

Linden Tibetts: It's about unlocking the power that's locked away within the services that we're already in. The information and the capabilities that other services, other partners, and our end users can use if there was a standard way to access those things. And, I think that's what it's all about.

TETRASCIENCE

Interview with **Alok Tayi**, CEO of TetraScience

PreScouter: ***Tell me about yourself and your organization.***

Alok Tayi: I have about 15 years of research experience, most recently as a post-doctoral fellow at Harvard. But 2 years ago I decided, along with my co-founders, that lab research needed radical modernization — and TetraScience has been tackling that ever since. TetraScience is the only mission control for R&D that helps you better use your time and equipment.

PreScouter: ***How is your company tackling the IoT challenge?***

Alok Tayi: We didn't set out to tackle IoT. We set out to tackle inefficiencies we experienced in scientific laboratories, and concluded that IoT could accomplish this. Unlike most IoT companies, we focus on a specific industry — scientific R&D. We enable researchers to connect their instruments to a single, online dashboard where they can manage experiments and access data.

PreScouter: ***What changes do you think IoT will bring to your industry?***

Alok Tayi: The opportunity in R&D is massive. It's an industry still heavily reliant on manual processes, which are inefficient and error-prone. Our customers estimate that 45% of R&D dollars are wasted: experimental deviations, delayed projects, and inefficient data management are the main challenges. We believe that connected labs and streamlined experimentation will eliminate these inefficiencies and accelerate science.

PreScouter: ***What is your estimate for the economic impact and growth of the IoT space?***

Alok Tayi: Overall, we don't believe there exists an "IoT space," per se. The reason is that IoT only creates value when connectivity is combined with a workflow innovation and a business model relevant to the end user. This combination (connectivity + workflow + business model) is specific for every industry. I believe the impact can be huge, as firms like McKinsey and Deloitte suggest. However, value will be realized within individual verticals. The industries to keep an eye on are those with many physical processes that

have informational related challenges. For scientific instrumentation, I believe it could be $12 billion. In science, I think the economic impact can be more than $112 billion.

PreScouter: ***In terms of your estimates for economic impact and growth of the IoT space, I want to confirm that the distinction between scientific instrumentation, and science in general is the industry R&D that's happening? Is that accurate?***

Alok Tayi: Yes. The market size for scientific instrumentation is about $44 billion a year. And that is the money that's spent on instruments, consumables, and services, so our technology can impact about 30% of that instrumentation industry. By making more valuable instruments, decreasing servicing costs, and adding new types of services onto those instruments. But the amount of money that's spent on scientific research globally is about $250 billion.

Of the $250 billion spent on research overall, the majority that's spent on people, infrastructure, training, and that sort of stuff. So, you ask, what kind of gains can you see when people are more efficient? When they're able to do more experiments in a given period of time, and come up with those new and unique insights.

If you look at 45% of that $250 billion, that's about $112 billion worth of impact when you have better data and better decisions as a result.

PreScouter: ***What does your company wish to accomplish within the IoT space in the next 5-10 years?***

Alok Tayi: Within 5-10 years you will see all scientific instruments connected to the cloud and TetraScience will be the primary mission control that connects the dots between data, insights, and outcomes. One way we'll accomplish this is by providing a cloud-based platform directly to manufacturers — we're already doing this today.

PreScouter: ***Which players operating or entering the IoT space do you think everyone should be aware of?***

Alok Tayi: I think the companies that are doing interesting things include June Oven, SmartBin, and Amazon Dash

PreScouter: ***These three companies are focused on the smart home and the residential market. We have seen***

a lot of media focus has been on the residential space as well. Do you think that's part of the larger trend, in terms of consumer culture, or do you think it's because these are subjects that tend to gain the most media attention?

Alok Tayi: It's an interesting question.

I'll first off start by saying that our thesis is that, at the end of the day, Internet of Things is going to become a vertical-to-vertical solution. Especially in a business-to-business (B-to-B) context, IoT only creates value when you combine the connectivity with a workflow innovation, and a business model that's relevant to the end user.

It's that package that creates value, and it's that package that's specific for industry to industry, vertical to vertical. I think the reason, at least, that we highlighted some of the ones on the list here, is because they demonstrate how consumer electronics technology can be applied to both the home, and in industrial settings, too.

SmartBin is looking at garbage collection, actually, in municipal and commercial settings, not necessarily just the home. I think what they've done is they've shown how connectivity can add new types of functionalities. But also enables complete rethinks of business models, both in consumer settings and in commercial settings as well.

That's why we think some of these companies are interesting to keep an eye on, and it's because they're at the forefront of rethinking that package for their given chosen area.

Now, touching upon the point of consumer versus B-to-B. My personal opinion is that there's a tremendous amount that B-to-B businesses can learn from consumer-facing companies. Namely around usability and design, aesthetics, as well as marketing. And so, I think those aspects of how consumers can interact seamlessly with those sorts of technologies in a consumer setting. I think it's something that we should glean insights from, when looking at how we deploy B-to-B solutions.

PreScouter: ***Which IoT technologies/offerings are you most excited about bringing on to the market?***

Alok Tayi: We are excited to help companies view what instruments are used and when, automate their experiments (e.g., chemical reactions, cell therapies, formulation development, etc.), and automate data acquisition.

PreScouter: ***Could you describe what you envision being the biggest challenges to making the transition to IoT?***

Alok Tayi: A big challenge is the diversity of instruments in labs. There are over 2300 suppliers of scientific instruments! Given that large number, we need to work to create common standards and support for the breadth of devices in labs.

PreScouter: ***Considering this, what kinds of barriers do you see to actually accomplishing this? In other industries, a consortium of different industry partners and governmental organizations is required to create these kinds of standards, as well as support from the public. Do you think within this space, we're going to be able to see all three of these different stakeholders working together to make this happen?***

Alok Tayi: With regards to creating standards that might work across all of these different scientific instrumentation devices in the labs, you'll have to contact, and really be able to integrate seamlessly with, a lot of different manufacturers. As well as, going through some government associations, as that's how standards are usually created.

PreScouter: ***Do you see any sort of roadblocks to making that happen?***

Alok Tayi: A lot of the challenge you're thinking to some extent, which is the assumption like in, say, the wireless and communication standards, is that a government body creates standards. Which, in fact, actually isn't entirely accurate. Standards are created based on usage, not based on standard spacing.

You'll probably hear a lot of folks in sales organizations, for instance, who say that they're standardizing on Salesforce. Salesforce is not a standard. It's just a platform, which is very convenient and valuable when it comes to managing the sales process. Its ubiquitous use amongst sales teams makes it an effective, de facto standard.

I think what we've seen is that in the context of the laboratory, our technology is used very heavily — to perform experiments, capture the data, and then perform some real-time analysis.
And, so, what ends up happening, is that, yes, you're absolutely right, there's tons of different types of instruments, but what we've been doing is opening up the APIs for the standards, for third parties to integrate themselves. I do think that the big roadblocks long-term are going to be finding the initial handful of cases that demonstrate the full potential of IoT in the lab.

From monitoring, to automation, to data capturing analytics, and then showing how any third party can put their own instruments, or a manufacturer can put their newly made instruments onto the same platform. That's where I think we see the real roadblock is getting that buy-in, getting that self-service contribution over time.

PreScouter: ***With the absence of government actually setting up those standards, doesn't that also mean that the whole industry can quickly shift to another standard in the future? Making it difficult to continue the adoption of your products?***

Alok Tayi: I think time will tell, which "standard" essentially emerges in this industry. Our view is, simply, that it will be a third party because of the different manufacturers at the table. Secondly, that our ability to quickly retrofit existing instrumentation, support existing instrumentation, as well as to be compatible with new instrumentation, gives us a leg up.

But, time will tell. I think a big part of it is also, when a scientist starts using TetraScience or using a cloud software platform, what we've observed, is that common platform creates more value when new instruments are put onto it. What we've been seeing, at least among our customer base, is demand for them to buy new instruments that have TetraScience already built into it.

These are some of the pieces that we started seeing that tend to snowball over time. At the end of the day, if a scientist has 50% of their workflow on one platform, they're not going to want to buy five others for the remaining balance of their work. I think it's that defensibility and that network effect, if you will, that creates some element of permanence over time, since the switching cost is fairly high.

PreScouter: ***Do you think manufacturers will try to push their own standards and close their platforms to try to start having that added value? Do you feel there is a risk that it's going to end up with users having to use several platforms? Or do you feel that in this particular field a third party that, as you mentioned can really work with different ones, is going to prevail, and manufacturers are going to see that as added value, instead of trying to push their own platforms?***

Alok Tayi: Our insight, so far, has been that when working with TetraScience, manufacturers earn a tremendous amount of value and revenue because their instruments become more valuable. They're able to earn recurring software fees associated with that connectivity and their applications on our cloud platform.

I think we are the enabling infrastructure to make that happen. I think what we've seen as the challenge for manufacturers is that, first and foremost; they're fundamentally hardware companies and not cloud software companies. So, it would cost them tens of millions in dollars to create the Nest-like experiences that we can do for a tenth or a hundredth of that amount.

Secondly, many of them don't have the know-how of selling and supporting that sort of infrastructure, especially given the IT and data security requirements of pharmaceutical companies, oil and gas companies, etc. What our customers love is that TetraScience goes through a security review and then all other instruments that plug to that same platform, get immediately waved through the door because of that initial security review. Now, imagine if a customer has to do a security review with every one of the 2,300 manufacturers assigned to make instruments for the U.S.? There's a lack of experience and lack of ability to meet a lot of the data security and IT constraints.

But lastly, our platform gives them the ability to create that added value and monetize it immediately.

We recently announced and launched our partnership with a manufacturer of sterilizers called Consolidated Sterilizer. We have a handful of other partnerships coming through by the end of the year. And, in the case of ConSteril, at least, they're seeing that they're able to increase their profit anywhere between 50% to double what they were getting now because of this connectivity.

Not to mention the ability to do interesting functions, like remote diagnostics and reporting, as well. We're starting to see those three things play into the buying dynamics. A lack of understanding of cloud software on the manufacturer's side, inability to sort of support a lot of data security requirements and the IT standards. And then, they are monetizing and finding a tremendous amount of value by being on our platform.

And the last point I'll mention is from a user standpoint. I don't think a user really wants to have a different application for their freezer, versus their incubator, versus their hotplate.

PreScouter: ***What are the biggest risks that will come with greater adoption of IoT within your sector?***

Alok Tayi: First, the value of connectivity is different from scientist to scientist and industry to industry. Scientists use 10-100 instruments on a daily basis from a number of different manufacturers.

Instruments must work on a common platform to be valuable to a scientist. No one wants to use a different piece of software for each of their devices.

PreScouter: ***How long has your company been involved in the IoT space?***

Alok Tayi: We have been working on IoT for R&D for the past 2 years.

PreScouter: ***What wide-area network do you envision your technology leveraging? How does this idea scale with demand (i.e., Wi-Fi-NFC, cellular, narrow-band, a mix)?***

Alok Tayi: Our hardware communicates to the cloud by Wi-Fi, Ethernet, or 3G/4G.

PreScouter: ***How does Big Data / Machine Learning pair with your technology?***

Alok Tayi: We see huge opportunities in leveraging big data and machine learning and AI. A historical challenge in science is that data used to be captured in paper — we are capturing it in an accurate, digital medium. As a consequence, we are now seeing huge opportunities in the following ways: evaluating instrument failure based on historical behavior (big data), and using aggregate data sets to learn how to perform new experiments (machine learning). In fact, we are about to embark on a project that leverages our IoT technology to digitize and automate chemical synthesis using artificial intelligence.

PreScouter: ***What is one factor that would accelerate adoption of your IoT technology / platform?***

Alok Tayi: A major accelerator for IoT in R&D labs is the integration of TetraScience technology directly into newly manufactured scientific instruments. TetraScience connects to existing instruments out in the field, regardless of manufacturer. But, we will see an explosion of adoption once more manufacturers integrate our IoT functionality before their products leave the assembly floor. Then, they are able to earn more revenue, have better visibility in to broken equipment, and deliver new, differentiated services.

PreScouter: ***What role do you think government should play within the IoT space (i.e., minimum standards for data encryption, etc.)?***

Alok Tayi: I think that the government has a responsibility to shine a light on areas where IoT can have an

impact. With broad visibility in to major problems (e.g., infrastructure, transportation, public safety, health, education), the government can elucidate areas where physical processes have informational challenges. These insights are important for entrepreneurs to direct their newly formed ventures.

PreScouter: ***As we see more perceived threats, and more abilities to actually provide some cyber security challenges to different IoT areas including scientific instrumentation, do you think that government involvement will become more necessary in the future?***

Alok Tayi: What I'll say is that right now I think that government has provided individual institutions the flexibility and freedom to decide how they want to store and manage their data. But it's interesting in that, I think less on the IoT security standpoint, but in certain industry of verticals, we're starting to see government step in and actually require more data.

For instance, in the context of pharmaceutical manufacturing for medicines, the government has had a long set of regulations called 21 CFR, which outlines how pharmaceutical companies should be collecting, storing and managing data, especially with new medicines coming to market, to ensure their safety in the marketplace.

We're seeing similar types of demands from the food industry, and food safety, as well. I think, what we're seeing is a little bit less around securing and encrypting data perhaps, but more around the ensuring that there exists the right quantity, the right types of data, and the right visibility into all the correct parties. Not just the manufacturer, but also the regulator as well.

I'd say government is certainly playing a bigger role, especially from a public health and public safety standpoint. And we're starting to see it not only in pharmaceuticals and medicine, where it's historically been, but also in new areas like food and beverages as well.

PreScouter: ***What safeguards are being developed to ensure there is data-privacy? Will customers have access to their IoT-device data?***

Alok Tayi: In our technology, we have multiple layers of security: multi-factor authentication, encryption, and continual authentication. Furthermore, we are exploring how to use predictive threat intelligence to detect issues ahead of time. Lastly, we provide the IT teams a dashboard of real-time device health and performance.

PreScouter: ***If you could convey one core concept about IoT to the C-suite across your customer base, what would it be?***

Alok Tayi: IoT value = connectivity + workflow innovation + business model

PreScouter: ***How does the information being created through your IoT technology create value?***

Alok Tayi: The process of using our IoT products and resulting data creates value by helping labs to improve their productivity, compliance, and quality.

PreScouter: ***What are your thoughts around the IoT adage, "your information is only as good as your sensors"?***

Alok Tayi: I do believe that to be true, however, in science, there is a tremendous amount of context that's important. What reagents am I using? What piece of equipment? When was it calibrated? What was the protocol?

PreScouter: ***What is the craziest idea you've heard around IoT / Industrial Internet?***

Alok Tayi: There are always clever makers coming up with new consumer hacks. There is a whole range of IoT trashcan hacks for example, it will email you when it's full, open the lid when someone approaches. There was one that would post a picture of your trash to your Facebook. It may sound silly but it's also indicative of the exciting time we're in. There are many inventors out in the world being very creative and exploring the potential of IoT.

PreScouter: ***Have you also seen a push or an interest from the manufacturers part on getting some of that usage data you collect? As you're collecting the data for the users themselves, could it be useful for manufacturers to try and improve their current equipment and services?***

Alok Tayi: Absolutely, and that's what is actually a benefit of working with a third party like us, where historically this kind of connectivity has existed for a long period of time.

Customers in industrial settings are concerned about having third parties have access to their intellectual property like their samples, their data information, that sort of stuff. So, what TetraScience actually does

is we give the end user, the customer, control of all the data that's being produced by the instrument.

And we separate the instrument operational data, like errors and serial numbers from the sample identifier, the experimental data, so that the customer can have confidence that all of their intellectual property is protected, while the manufacturer also benefits from being able to see how often the system is breaking, for instance.

This, not only helps the manufacturer in improving that product, but also delivers a higher tier of customer service as well. We've seen a huge amount of interest and opportunity in that area as well.

PreScouter: ***Any final thoughts / anything we failed to address?***

Alok Tayi: I'd definitely say having sort of seen IoT and people talk about it, I guess we have somewhat of a contrarian view in that I don't really know if there necessarily exists an "IoT space."

I think there, however, are different industries that can leverage again, the connectivity, to influence the workflow that's associated with their technology, as well as a new type of business model that can, and would disrupt industries fundamentally. I really think it's important to consider how IoT is going to be specific for each of those individual protocols, and I think those that are the most exciting are those that have no dominant players.

If you look at industries like farming or commercial cooking, you have two or three players who dominate 80 to 90% of the market. Though they have a large market share and a lot of probably technical R&D investment, the dynamics are going to be pretty staid. Those guys will probably still be the ones who deploy and find value in IoT.

If you look at industries like ours where there are thousands of different players and it's very fragmented, much like other industries. I think you're going to see some really unique dynamics happen where customers that start demanding this feature, and are actually going to be driving the industry forward, which probably creates an opportunity for new entrants and new business models as well.

GE Healthcare

Interview with **Bill Shingleton**, Technical Lead at GE Healthcare

PreScouter: ***Tell me about yourself and your organization.***

Bill Shingleton: 'm a biological scientist by background, working in R&D for GE Healthcare's Life Sciences' Core Imaging business. We manufacture contrast media and imaging agents for use in diagnostic imaging. Core Imaging is one of five business units within Life Sciences, and Life Sciences is one of three businesses that make up GE Healthcare.

PreScouter: ***How is your company tackling the IoT challenge?***

Bill Shingleton: GE's digital platform is Predix, for Healthcare there is GE's Health Cloud. Core Imaging is working to understand how best to deploy this technology into diagnostic and care pathways.

PreScouter: ***What changes do you think IoT will bring to your industry?***

Bill Shingleton: Connectivity, more optimal data utilization, greater support for clinical practitioners, and, thus, better outcomes for patients.

PreScouter: ***What is your estimate for the economic impact and growth of the IoT space?***

Bill Shingleton: Tackling the interoperability of systems could save healthcare ecosystems $30 billion per year. Healthcare data is predicted to grow 50 times by 2020.

PreScouter: ***What does your company wish to accomplish within the IoT space in the next 5-10 years?***

Bill Shingleton: Enable a shift from hospital centric operational model (fee for service) to a collaborative patient centric model (outcome driven).

PreScouter: ***Which players operating or entering the IoT space do you think everyone should be aware of?***

Bill Shingleton: The small start-ups developing the solutions we haven't thought of!

PreScouter: ***Which IoT technologies/offerings are you most excited about bringing to the market?***

Bill Shingleton: The platforms and digital solutions that enable those close to the patients to develop (or have developed) applications that make a difference to patient outcome.

PreScouter: ***Could you describe what you envision being the biggest challenges to making the transition to IoT?***

Bill Shingleton: Culture change within established organizations, both for healthcare providers and their suppliers. Building trust that patients' data will be secure and used in the most appropriate manner.

PreScouter: ***What are the biggest risks that will come with greater adoption of IoT within your sector?***

Bill Shingleton: Data security, lack of collaboration, and clinical practitioners believe technology is trying to replace them.

PreScouter: ***How long has your company been involved in the IoT space?***

Bill Shingleton: Close to 10 years, I believe.

PreScouter: ***What wide-area network do you envision your technology leveraging? How does this idea scale with demand (i.e., Wi-Fi-NFC, cellular, narrow-band, a mix)?***

Bill Shingleton: Sorry, you're asking a biologist! But, a mix, I would think.

PreScouter: ***How does Big Data and Machine Learning pair with your technology?***

Bill Shingleton: It is integral — it's what Predix and the Health Cloud is designed to do.

PreScouter: ***What is one factor that would accelerate adoption of your IoT technology or platform?***

Bill Shingleton: Collaboration.

PreScouter: ***What role do you think government should play within the IoT space (i.e., minimum standards for data encryption, etc.)?***

Bill Shingleton: Yes, setting standards, offering guidance around software in a medical device context, encouraging cooperation.

PreScouter: ***What safeguards are being developed to ensure there is data-privacy? Will customers have access to their IoT-device data?***

Bill Shingleton: Military-grade security as standard, and yes, customers will have access to their data.

PreScouter: ***If you could convey one core concept about IoT from the C-suite across your customer base, what would it be?***

Bill Shingleton: We can enable digital solutions at industrial/sector-level scale.

PreScouter: ***How does the information created through your IoT technology create value?***

Bill Shingleton: Maximizing the potential of customer data leading to more optimal deployment of resource, efficiencies, clinical support, and better patient outcomes.

PreScouter: ***What are your thoughts around the IoT adage, "your information is only as good as your sensors?"***

Bill Shingleton: True, but this is the same for all data-driven activities, the output can only as good as the input.

PreScouter: ***What is the craziest idea you've heard around IoT or the Industrial Internet?***

Bill Shingleton: Computers will replace clinical practitioners, no! Enable and support, yes!

FUTURE DIRECTIONS / CONCLUSIONS

The Internet of Things will bring large changes to every industry, and will create huge opportunities and value for those firms that are able to capitalize on this need. As the IoT is still in a nascent stage, we are currently seeing several battles for dominance within the various submarkets that make up the IoT sector:

- In the IoT platform markets between large entrenched players like Cisco, GE, Microsoft, and Google.
- In the cloud data markets between large entrenched players like Amazon and Microsoft.
- In the communications protocol markets between large entrenched players like Siemens and Rockwell Automation.

As the Internet of Things continues to grow, it will affect many other industries. Some of the secondary markets impacted by the growth of IoT include:

- **Energy** - All the new IoT devices continuously monitoring and recording data will require power. The need for novel, more compact, and less expensive energy storage devices will continue to increase, and the energy storage market will likely benefit from this demand.
- **Big data** - Storage, analytics, infrastructure, and security markets will all increase in size to meet demand from IoT. The RFID market will grow due to increased adoption, especially in the retail industry.
- **Advertising** - The advertising market will start to become one of largest customers for IoT data.

PRESCOUTER

www.prescouter.com

1 N Franklin St, Chicago, IL 60606

P: (872) 222-9225

E: solutions@prescouter.com