

How can we recognize the real power of the Internet of Things?



If policy makers and businesses get it right, linking the physical and digital worlds could generate up to \$11.1 trillion a year in economic value by 2025.

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The Internet of Things (IoT) has the potential to fundamentally shift the way humans interact with the world around them. IoT systems, which we define as sensors and actuators connected by networks to software, can monitor and manage connected objects, machines, and even living things. This rapidly advancing technology makes it possible to apply data-driven decision making to new realms of human activity. From monitoring machines on the factory floor to tracking the progress of ships at sea, sensing changes in physical environments to keeping closer tabs on human vital signs, IoT systems can enable companies to get far more out of their physical assets, revolutionize how we run our cities and homes, improve health outcomes, and even save lives.

Much has been written about IoT in the past five years. Advancements such as the development of self-driving cars, fitness bands to monitor physical health, and Internet-connected devices such as smart thermostats to manage our homes have given us a glimpse of what the future might hold. Technology suppliers have begun ramping up their IoT businesses and creating strategies to help customers design, implement, and operate complex IoT systems. Manufacturers, oil and gas companies, and other businesses have already begun to see the initial payoff from introducing IoT systems to their own operations and supply chains.

For all the attention that this emerging technology has received, the hype may actually understate the long-term potential of

IoT systems. At McKinsey, we estimate that by 2025 IoT will have a potential total economic impact of as much as \$11.1 trillion per year. In fact, IoT will be the biggest source of value of all disruptive technologies, ahead of mobile Internet, knowledge-work automation, cloud computing, and advanced robotics (Exhibit 1).

The impact of IOT systems will vary by setting. Factories and cities, for example, stand to benefit the most. Capturing the maximum benefits of IoT will require an understanding of where value can be created, and successfully addressing some complex challenges such as interoperability and data issues. But it is clear that what first emerged as a connectivity solution has given birth to a dynamic industry

that extends beyond the borders of the traditional technology industry.

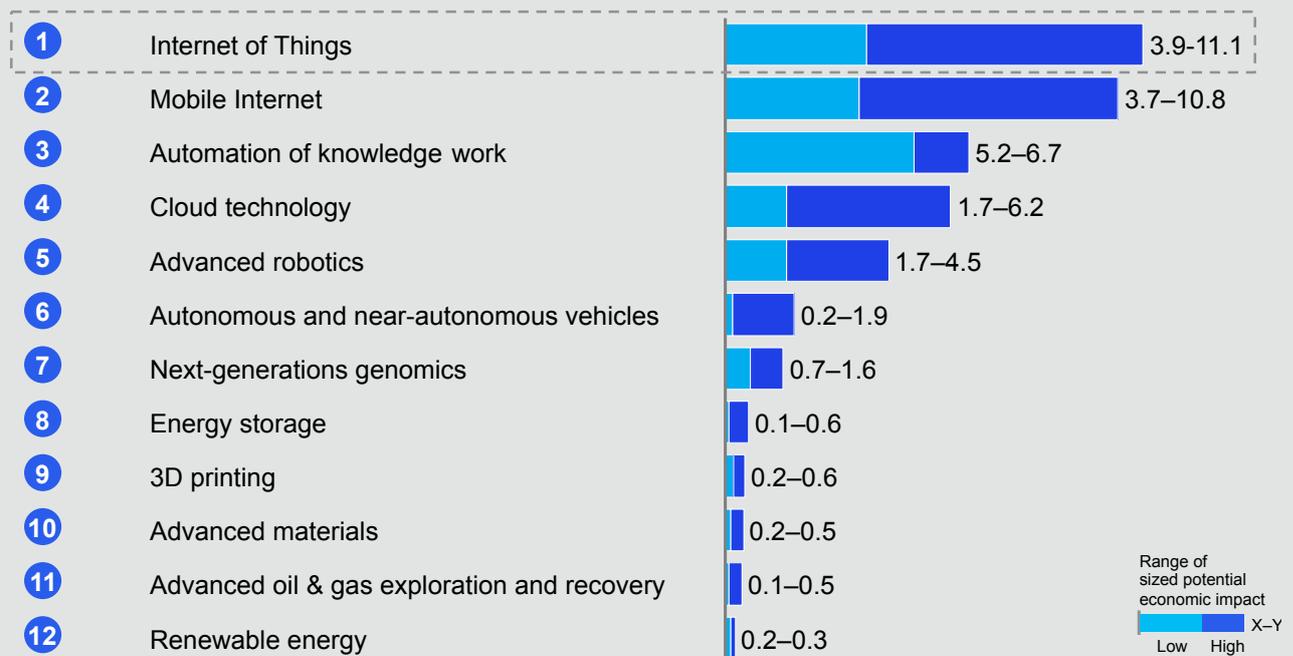
The wide world of IoT applications

Looking at the potential of IoT through the only the lens of the vertical industries in which they might be deployed does not reveal the full picture of its potential value. By instead examining the physical settings in which IoT technologies might be applied, such as worksites, homes, or the outdoors, we can analyze the full spectrum of IoT's potential benefits and challenges (Exhibit 2).

Of these settings, factories and other process-driven production environments such as

Exhibit 1

Internet of Things will have substantial economic impact by 2025 among a list of disruptive technologies



SOURCE: McKinsey Global Institute

Exhibit 2

A “settings” lens helps capture all sources of value; we identify nine settings where IoT creates value

Setting	Description	Examples
 Human	Devices attached to or inside the human body	Devices (wearables and ingestibles) to monitor and maintain human health and wellness; disease management, increased fitness, higher productivity
 Home	Buildings where people live	Home controllers and security systems
 Retail Environments	Spaces where consumers engage in commerce	Stores, banks, restaurants, arenas—anywhere consumers consider and buy; self-checkout, in-store offer, inventory optimization
 Offices	Spaces where knowledge workers work	Energy management and security in office buildings; improved productivity, including for mobile employees
 Factories	Standardized production environments	Places with repetitive work routines, including hospitals and farms; operating efficiencies, optimizing equipment use and inventory
 Worksites	Custom production environments	Mining, oil and gas, construction; operating efficiencies, predictive maintenance, health and safety
 Vehicles	Systems inside moving vehicles	Vehicles including cars, trucks, ships, aircraft, and trains; condition-based maintenance, usage-based design, pre-sales analytics
 Cities	Urban environments	Public spaces and infrastructure in urban settings; adaptive traffic control, smart meters, environmental monitoring, resource management
 Outside	Between urban environment (and outside other settings)	Outside uses include railroad tracks, autonomous vehicles (outside urban locations), and flight navigation; real-time routing, connected navigation, shipment tracking

McKinsey&Company | Source: McKinsey Global Institute analysis

hospitals and farms, are likely to reap the greatest benefits from the adoption of IoT systems—as much as \$3.7 trillion by 2025. In this type of venue, which includes any standardized production environment, the value will come from improvements in energy efficiency, labor productivity, equipment maintenance, inventory optimization, and worker health and safety (Exhibit 3).

Cities have become the locus of a great deal of innovation and experimentation in IoT technology with the introduction of “smart city” initiatives. Since cities are the engines of global economic growth—the 600 largest cities in the world are expected to generate 65 percent of global GDP growth through 2025—the impact of IoT technologies here can be substantial.

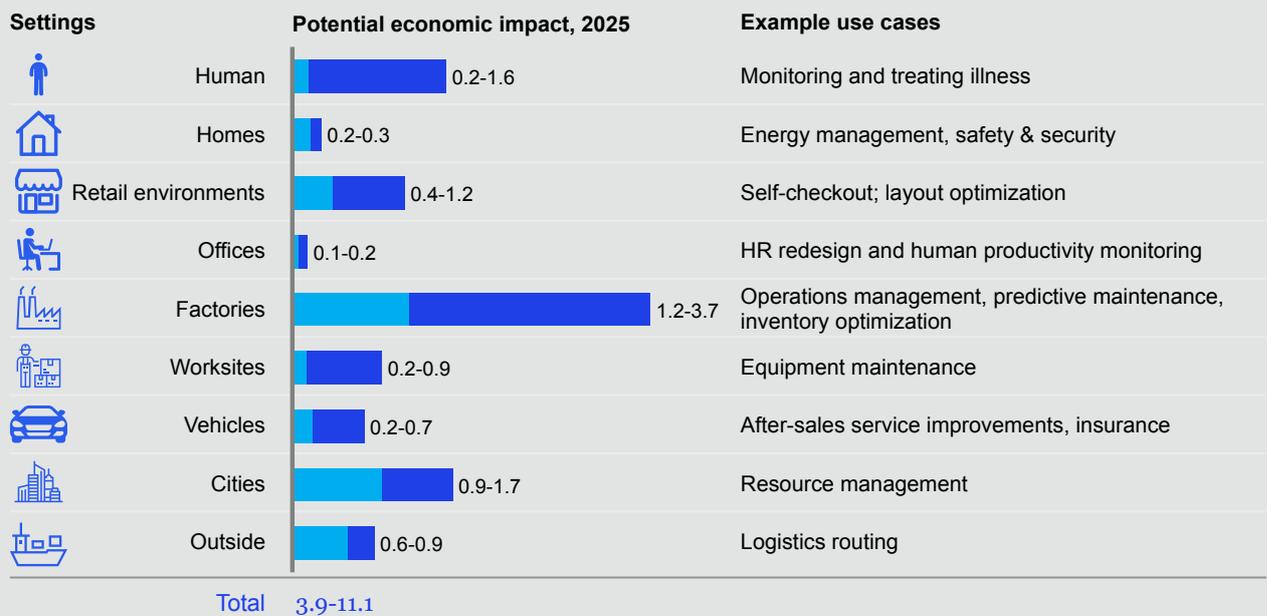
The municipal setting is likely to be the second-largest beneficiary of IoT improvements with potential impact as great as \$1.7 trillion by 2025. Those benefits will come from improvements in transportation, public safety and health, resource management, and service delivery. IoT transportation applications alone could be worth more than \$800 billion per year to cities around the world, while public health IoT systems could yield \$700 billion per year mainly from air and water quality improvements.

While consumer uses of IoT technologies such as smart watches or fitness trackers have garnered the most mainstream media coverage, business-to-business applications actually have greater economic potential, and will account for about two-thirds of the

Exhibit 3

We view IoT via “physical settings.” Potential economic impact of IoT in 2025¹ is \$4-11 trillion.
\$Trillions 2015 dollars

 Key issue: how to unlock incredible value potential in each setting



¹ Includes sized applications only; includes consumer surplus

SOURCE: McKinsey Global Institute

value of IoT investments within the next ten years. A great deal of additional value can be created when consumer IoT systems such as connected consumer healthcare products are linked to B2B systems, like services provided by health-care providers and payers.

IoT software takes center stage

A dynamic industry is emerging around IoT technology. While IoT began as a connectivity technology, the payoff today and in the future will be derived from other aspects of fully formed IoT solutions, most notably in the highest growth areas of software applications and security. While connectivity accounts

for as much as 10% of the market today, that sector of the IoT market is flat; hardware, which accounts up to 30% of the market, is decreasing, according to McKinsey analysis. Software and application development, on the other hand, account for as much as 35% of IoT value and are predicted to grow in the future. Security makes up just 5% of the market, but is an important and strategic layer of IoT solutions, given customer concerns with opportunities for both incumbents and emerging players (Exhibit 4). The market for IoT components and systems grew 160 percent in 2013 and 2014, and could grow at an annual rate of 30 percent or more through 2025. There will be rising demand for the vertical expertise required

Exhibit 4

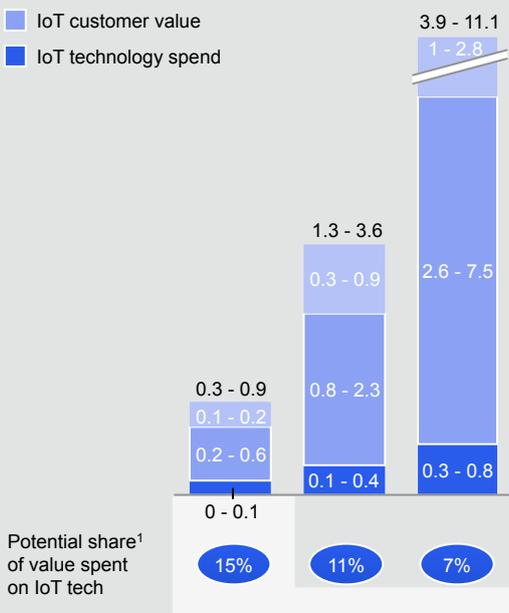
Most of the value is beyond connectivity.

ESTIMATES ACROSS SECTORS & SETTINGS

IoT potential economic benefit

\$, Trillions per year

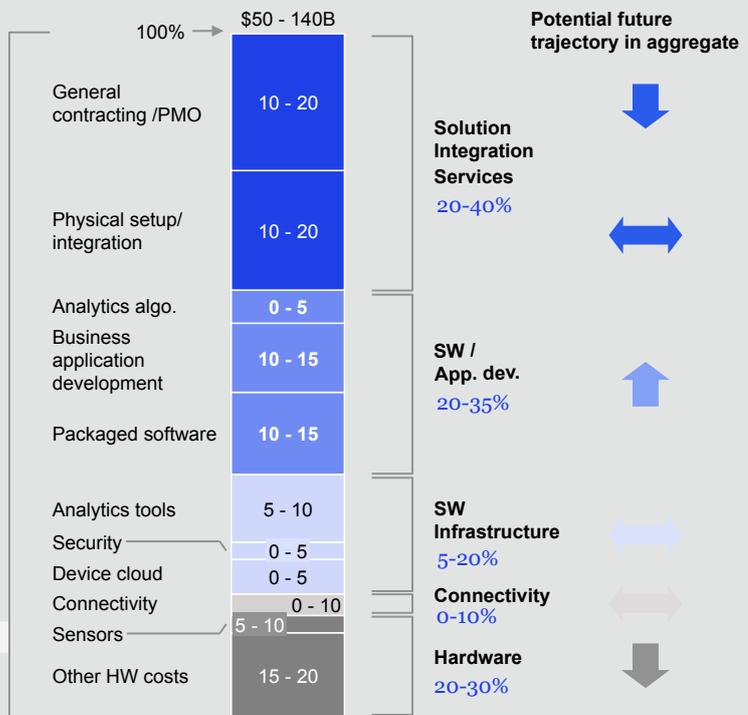
- Consumer surplus
- IoT customer value
- IoT technology spend



Increased competition will drive down the overall share captured by the IoT value chain

Amalgamated IoT value chain revenues in 2015 based on industry interviews

Percent



¹ One possible scenario; IoT technology spend includes internal technology spend by IoT customers

SOURCE: Industry interviews; McKinsey analysis

to help companies in specific industries incorporate IoT technology into their processes. Technology suppliers will also play an important role in developing standards and protocols to enable the interoperability that is essential for maximizing IoT benefits.

At this early stage, it's unclear what the winning approaches will be, and IoT business models will evolve over time. As is typical with technology innovations, from PCs to the Internet, there will be phases. In the first, suppliers have succeeded by providing the building blocks of the IoT infrastructure. In the second phase, companies build broadly scaled applications. In the third phase, companies build adjacent businesses.

In the current environment, and given the complexity of IoT systems, the limited capabilities of many customers to implement them, and the need for interoperability and customization, there is ample opportunity for hardware, software, and service providers to provide end-to-end IoT solutions that help customers meet specific needs. Over time, more horizontal platforms may emerge, though. As the industry matures, the sources of competitive advantage will likely include distinctive technology, distinctive data, easy-to-use software platforms, and the ability to provide complete solutions.

As digitization blurs the lines between technology vendors and other companies, there are also openings for non-technology vendors to enter this market. Makers of industrial machinery or auto manufacturers, for example, can create new business models by applying IoT data and solutions to offer their products as a service.

As the value of IoT technology shifts from hardware and connectivity to software and analytics to make use of the data collected and sent, IoT players will need to expand their

expertise across all layers of the value chain to build sustainable propositions. That will require them to either master these capabilities or work with partners who have this expertise.

IoT snapshot: reimagining the in-car experience

There are hundreds of use cases for IoT systems in each setting. In the vehicle space, which could generate up to \$740 billion per year within the next decade, we have identified 30, from improving safety to increasing convenience. Taking a closer look at how the connected car can make driving more social gives us a view into what some of the key success factors for IoT systems enablement might look like in action.

As driving becomes increasingly autonomous, the human in the driver's seat will have more time on his or her hands. IoT-enabled connectivity opens the door to achieving a customer-focused outcome: making the driving experience more fun. The data generated by the car can be enriched to serve as the foundation of a social experience among drivers. With access to a driver's location, driving style, pictures, and other data taken directly from the driver as well as from the original equipment manufacturer, IoT platform providers can offer participating drivers an interactive experience similar to that enabled by the search-and-discovery service Foursquare. With in-car screens and augmented reality as the interface, this type of data also has the potential to support increased interactivity. While the focus of this use case is on the benefit to the customer, this approach can pay off for companies that control the data in a social driving market that is expected to reach a value of as much as \$8 billion dollars by 2030.

In order to capitalize on these benefits, of course, companies will have to consider the interoperability of the systems required to make

it happen. That will require investments in new car technologies such as cameras to capture the driver's image and other sensors, as well as in a communications platform. A variety of companies could cooperate and compete in this arena with potential players including OEMs, suppliers, gaming software houses, telecom providers, and even big social media players who would benefit from in-car access to users.

The possibility for these companies to actually capture the value from the social driving market will hinge on their ability to put this data to work by establishing themselves in the new car data value chain and gaining access to customer data. Whoever gets access and shapes the key control points will be best-positioned to reap the benefits of the social driving market.

Key success factors

Whether the setting is a connected car, an intelligent office building, or an offshore oil rig, a number of obstacles will need to be overcome for IoT systems to deliver their maximum value. Some of these issues are technical. Others are structural. Still others are behavioral. Consumers, for example, need to trust IoT systems, and companies must embrace the data-driven approaches to decision making that IoT technology enables. In addition, regulatory issues (such as determining how to deal with autonomous vehicles) will need to be resolved and standards developed.

Not all these sticking points are under the control of the companies that hope to benefit from IoT systems. But there are four key best practices that companies who want to derive the full benefit of IoT systems can adopt:

1. Focus on outcomes

We may soon live in a world where everything is Internet-connected. The opportunities to collect data about the world around us is

seemingly endless. For that reason, successful companies will focus first not on the data they can collect, but on the outcomes they want to achieve. In aviation, the outcome may be reduced downtime from maintenance, or better passenger safety. In logistics, the goal may be more on-time deliveries or optimized routes.

An automotive company may want to improve safety ratings or vehicle reliability.

Taking a design thinking approach, an iterative approach to development that starts first with the problem to be solved, can be beneficial. By starting from the needs of customers or users instead of a piece of new technology, companies can then home in on the possibilities of IoT technology to meet those needs and the requirements for business success.

2. Master interoperability

Interoperability may be the biggest success factor in any IoT implementation. An average of 40 percent of the value of IoT initiatives depends upon multiple IoT systems working together, according to McKinsey's analysis. In the worksite setting, 60 percent of the potential value hinges on the ability to integrate and analyze data from various IoT systems.

In order to determine where to play, a company must look at the end-to-end value chain which will deliver an outcome to a customer. Then they will need to determine which parts of it—which control points—they should own, and which are better addressed through outsourcing, long-term collaboration, or other types of partnerships.

The possibility of capturing value from the social-connected car for instance, will depend on the company's ability to establish itself in the new car data value chain and gain access to customer and car data. The critical control points in this case are the human-machine

interface, the data gateway and the customer ID. Whoever gets access to and shapes these control points is in the best position to capture value.

3. Put IoT data to work

An IoT solution is not one that simply collects and transmits data, but one that analyzes that data to solve problems or create new opportunities. Companies can create competitive advantage with IoT technology by owning the data or algorithm that defines a beneficial outcome.

Today, very little of the data generated by Internet-connected things are actually used, and those data that are used are not fully exploited. The oil and gas industry, for example, which has as many as 30,000 sensors on a single offshore oil rig, is using less than one percent of the information gathered from those devices for decision making, according to McKinsey. And most of the data that are used—for example, in manufacturing automation systems on factory floors—are utilized only for real-time control or anomaly detection.

Organizations that want to reap the full benefits of IoT technology will need better tools and methods to extract insights and actionable information from IoT data, most of which are not widely used today, such as advanced analytics and artificial intelligence capabilities. Embedded intelligence will be key to integrating

IoT into business processes and engaging users.

There's a tremendous amount of additional value waiting to be tapped to transform business processes or build new business models by using more data or deploying more sophisticated IoT applications. Performance data can be used for predictive maintenance or to analyze workflows. So-called "exhaust data" generated by IoT applications can become a profit center itself. Almost any data describing consumer behavior can be of great value to marketers. Data about physical assets, such as buildings and vehicles, can be used to assess insurance risks. One company's data trash may be another's data treasure.

4. Start small and scale up

Companies that try to build the ultimate enterprise IoT solution off the bat today will fail. There are no end-to-end solutions today, and building one from scratch would be a formidable task. In these early days, companies are best served with a test-and-learn approach, starting small with simple but clear use cases and expanding from there. The best approach is to focus efforts on a limited number of use cases and then apply the resulting momentum and best practices to fuel more complex use cases in the future.

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