

# Making the **Internet of Everything** a Reality

A Skyhook Whitepaper

**SKYHOOK<sup>®</sup>**

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A background network diagram consisting of numerous light blue nodes connected by thin lines, creating a complex web of connections.

# Introduction

We are at a critical point in the evolution of both the IoT market and the platforms that are developed to support it. The Internet of Things, Industrial Internet of Things, Internet of Objects and Internet of Everything have evolved from mere buzzwords to a new reality - one that's approaching faster and at a larger scale than we thought possible, with McKinsey suggesting that the total IoT market will be between \$3.9 and \$11.1 trillion by 2025.

This guide provides companies interested in IoT a jump start into the concept, covering a brief history of the space, areas of growth and successful use cases. The company that focuses on bringing new insight to their business processes and finds more efficient ways to operate will be the most successful. Before we begin, it's essential to understand the factors that have brought us to such a turning point in the business of connected things.



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## WHY NOW?

Until recently, many machines and devices have operated in isolation, unable to communicate or share information between them or with their operators. While Machine to Machine (M2M) has been around for some time, its use has been largely managed by enterprise businesses such as Honeywell or GE. IoT on the other hand has now become a mainstream technology that takes into consideration the communication between all connected devices on both an individual and a macro level. In a lot of ways, IoT is to M2M what the cloud is to datacenters -- it vastly changes the ecosystem and accelerates customers' ability to optimize and execute on their business objectives.

Here are four key dimensions that are rapidly evolving and will continue to have a dramatic impact on the proliferation of IoT moving forward:

### 1

#### Hardware & Sensor Costs

Hardware and sensor costs have fallen drastically, allowing both large and small devices to join a connected network easily. The need for more efficient sensors that integrate seamlessly into existing devices and architectures is forcing a paradigm shift among hardware developers. Key metrics in power consumption, size and weight, now need to scale down 10X to 100X in order to keep pace with the growing market demands ([IEEE](#)).

In addition, the pace of innovation on reducing costs and power while creating new types of sensors and actuators is astounding. According to Allied Market Research, the MEMS market is expected to grow to \$26.8 billion by 2022, growing at a CAGR of 11.1% (source: [Sensors Online](#)). This innovation will continue to provide new capabilities that expand the scope of what can be done with IoT.

Companies, device manufacturers and IoT platforms need to understand how to combine shrinking hardware with sensors and actuators to solve specific use cases and how the different components can impact both cost and functionality. Keep these questions and metrics in mind when choosing partners and vendors to fuel your solutions.



## 2

### Networking and the Internet

With a proliferation of network connectivity options available, finding an affordable one to ensure your devices can get you the information you need at the frequency your business demands has never been easier. Today you can choose from IoT-specific LTE options from traditional cell carriers to dedicated Low-Power Wide-Area Networks (LPWAN) for IoT or simply make use of an existing Wi-Fi network.

Getting devices connected is certainly part of the puzzle, but being connected to the Internet vastly simplifies the solution. By 2008, the number of connected things and devices eclipsed the world population (Source: [Postscapes](#)), sparking fires across social media and large organizations calling for new use cases and ways to consolidate this massive amount of information. The pace and impact of adoption of a myriad of devices has done nothing but accelerate. Aside from changing our way of life, the Internet is continually redefining the way we do business.

Ensure you explore connectivity options when designing your solution, keeping an eye on cost, geographic coverage, and data demands.

## 3

### Location

Location is a critical element for many IoT solutions and thanks to technology advances, there are many different options for ensuring that your data includes the location information you need to make important business decisions. These positioning solutions go far beyond the traditional GPS/GNSS capabilities, and have varying accuracy, power, and network profiles. These options include Wi-Fi, BLE, Cell, and network-based positioning system.

While various high-performing location solutions are available in the market today, it is even more critical for IoT specific applications to consider the requirements and limitations of the particular use case in order to select the most appropriate location technology to integrate.

Some of the factors to consider are the usual suspects: power consumption/battery life requirements, hardware/sensor selection and cost, and network bandwidth limitations and cost. However, there are several other factors which need to be thought through completely that in many cases are overlooked. The below diagram represents just a few of the many dimensions to contemplate when defining and evaluating location solutions for your IoT application.

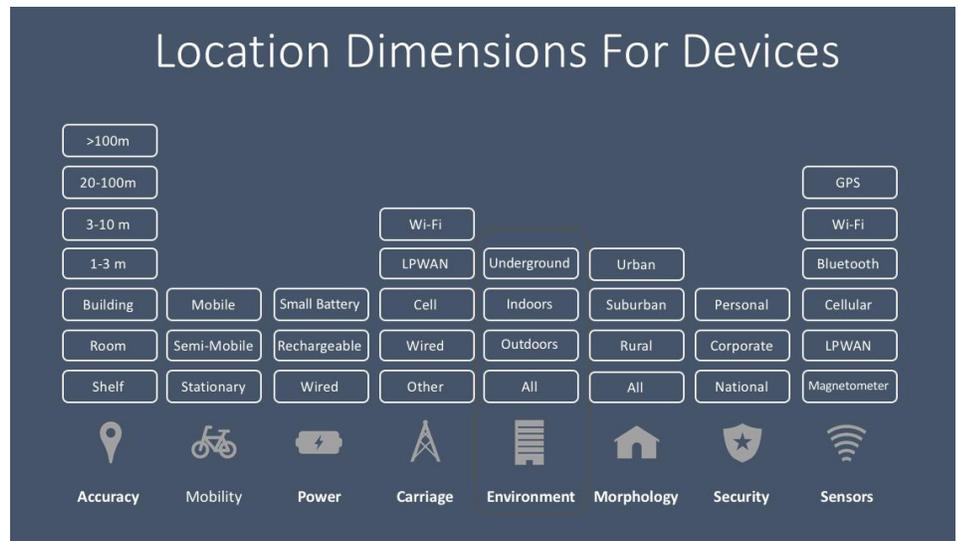


Figure 1: Considerations for location in IoT solutions ([reference to the webinar goes here](#))

While all of these dimensions play a part in the decision process, note that for IoT in particular, the network carriage dimension is most critical. Several of the LPWAN options available have extremely low bandwidth and payload capacity -- with a commensurate reduction in cost. However, it does force a byte by byte decision on what data is transferred and when. This can come as a shock for those having grown up with modern networks but can be an effective path depending on your use case.

## 4

### Cloud Services and Data Storage Costs

It wasn't until the birth of smartphones in the late 2000's that we realized the kind of data that could be enabled by connecting devices to the Internet. Mobile quickly overtook desktop media viewing time, and people now spend [an average of 2.8 hours a day](#) and produce over 25 quintillion bytes of data daily. The mobile phone quickly led to the creation of wearables and provided the basic framework for connecting every "thing".

One of the main drivers of IoT advancement has been a drop in data storage costs. Cloud-based storage is one of the key components driving innovation in IoT. For example, in 2010 it cost approximately \$80,000 to store one petabyte of data (that's 1 million GBs - for perspective, 50 Petabytes would house every written work of humankind in all languages). By 2020 the cost of one petabyte of data storage will be \$4.

While that may seem like ample space, consider that connected sensors can be generating millions of logs over the course of a day and the speed at which data is created is accelerating rapidly! The [IDC & EMC predict](#) that the amount of data stored will increase by a factor of 10 between now and 2020. In addition, all of those observations should be stored in a way that makes them easily accessible. With the cost reduction in data storage, you now have more freedom to consider what data you need to acquire and how you need to use that data for your business.

The growth of cloud computing and the available solutions that run on top of these services provide a convenient and always available environment to handle your data needs. Indeed many of these cloud providers already offer IoT services in a ready-to-use fashion. The Cloud computing market is projected to reach \$411B by 2020 (Source: [Forbes](#)) promising continual innovation both within the market but also on top of these platforms.

The foundations for the IoT explosion have been set, but companies will need to consider hardware and sensor technology, network connectivity, location technologies and cloud services as they formalize use cases and choose partners.

Considering how far the industry has come and that IoT deployments can take years to come to fruition, driving future-forward thinking is imperative at every level of your implementation from sensors to security to network infrastructure.

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## WHAT WILL IoT ACCOMPLISH?

It's important to examine why IoT is such a game changer. By collecting insightful data on operations down to the minute detail, business decision makers have access to a new level of knowledge as they plan their overall strategy. In fact, it's already been proven that broader access to data improves efficiency, reduces costs through optimization and gives businesses competitive advantages.

Companies that embrace IoT may see huge changes to their business or pricing models, so partners should be ready to make those accommodations. The ability to derive insights from previously untapped legacy assets will make way for the development of more service-based models. There will also be a new wave of consulting services designed to help organizations adapt, so seeking out those services may be a great first step.

A great example of this comes from the Forrester publication [The Internet of Things Heatmap 2016](#) where “Kaeser Compressors used sensor-enabled air compressors to transform its business model into a product-as-a-service. It now offers compressed-air-as-a-service for customers that would rather pay for compressed air as they use it, rather than buying and maintaining compressed-air equipment.”

Kaeser's entire business model changed with the addition of communicative technology. Beyond adding an air compressor service, they're able to offer preventative maintenance for their equipment buyers. This had an effect on everything from their pricing, to machine capacity and revenue streams.

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## MARKET OPPORTUNITIES

The downside of such a massive opportunity? Lack of clarity on where to focus efforts in operationalizing IoT. Many research organizations are predicting huge revenue growth in IoT, but with little detail on the applications or use cases in each industry. This lack of clarity should provide warning to organizations that are looking to jump into IoT without fully thinking through the unique use cases for their industry and business.

With so much growth potential in each industry, it's safe to say that no single vertical will dominate the IoT market. We compiled some of the market opportunities within IoT using some more credible bottom-up approaches from industry analysts.

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## FACTORIES

There is one general consensus amongst researchers—that the Industrial Internet of Things (or IIoT) will provide the most value in terms of insightful data, drastic reduction in costs and increase in profits.

One of the key benefits that come from connecting manufacturing machines is unlocking the data that previously went untapped and uncollected.

For instance Rick Lisa, Director of Worldwide IoT Business Development at Intel, explained at IoT World that after instrumenting one machine on their factory floor, they monitored the conditions of its output productivity and tuned the internal workings of the machine. Based on these adjustments, they were able to improve machine productivity by 95%. This saved the company over \$9 million in one year as a result.

Intel has thousands of machines across dozens of factories, so the cost savings for them is extremely significant. The benefit of connecting devices is truly realized at scale, when the benefits overwhelm the initial investment.

In order to determine the value of instrumenting machines in any given use case, it's important to think through every factor that's involved in setup:

- Expected annual savings from new system - both monetary and productivity gains
- Cost and time needed to install and maintain necessary hardware or software
- Cost of implementing security requirements and other risk mitigation procedures
- Time and resources needed to execute
- Training time needed for teams affected by the change

On the technical side, factory and manufacturing verticals are leading the way in bringing computing to the “edge” in IoT implementations. There is a focus on putting as much intelligence as possible in the end device, part, or machine in order for the unit to make intelligent decisions autonomously and determine the most appropriate information to send to the cloud or central servers.

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## HEALTHCARE

Connected platforms and devices can improve some of the healthcare industry's main challenges by reducing costs and improving patient care. According to [Andy Castonguay, Principal Analyst at Machina Research](#), the U.S. has the highest spending per capita for healthcare in the western world: 22% of America's GDP was spent on healthcare between 2014 and 2015.

Preventative medicine is a growing area in need of IoT innovation. Devices created to monitor patient medicine intake - such as a smart inhaler that measures dosage inhaled and frequency - can [reduce acute care visits from between 15-20%](#). However, the need for a more efficient “Feedback Loop” of using the data produced by users and machines to improve healthcare is inhibited in many ways.

Connecting devices between users and doctors is one way to solve this, but the need for FDA approval provides another challenge for companies looking to enter this space. It will be important when implementing IoT in healthcare to look for partners who are considering FDA-approved data. Despite this additional hurdle, there have already been some innovative uses for device data in this space.

One such healthcare example comes from [John Hancock and Vitality](#), where they are redefining life insurance policies by introducing wearable data into their policy considerations. The program requires policyholders to take a fitness test in order to receive tailored health goals. These goals can be attained by easily logging activities using online and automated tools, which are integrated with wearable devices. In fact, John Hancock gives every new customer a free Fitbit as an easy way to track their progress. This innovation has now evolved to become known as ‘Connected Insurance’. The marrying of consumer and enterprise IoT data will become increasingly popular as use case results surface, so keep an open mind when evaluating solutions in this space.

[Location technology has also become an essential tool used to help solve many problems within healthcare in particular from asset tracking, to patient care, home assistance, and drug distribution.](#) We’ve seen numerous cases in which new healthcare devices are integrating location as a component for compliance or operational optimization purposes.

Healthcare facilities are tagging or integrating software into devices, when possible, in order to assist in recording custody, enforce required cleaning procedures, or simply minimize lost assets such as wheelchairs or crutches. On the personal safety side, devices such as the GoSafe of [Phillip’s Lifeline Response Associates](#), combines Wi-Fi positioning, GNSS, cell tower, IP and device sensor data. The GoSafe solution takes advantage of hybrid positioning technology to intelligently choose the best way to provide precise location data and return the fastest time-to-fix location. Using an intelligent solution, the device is not always on: it simply turns on intermittently to gather location data. When the device is activated, whether through fall detection or manually, it turns on immediately and can report a precise location to emergency services while maintaining suitable battery life.[KN7]

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## ASSET TRACKING

Supply chain companies are rapidly adopting connected devices to provide basic asset intelligence. Reducing costs and improving delivery times for the shipping of goods will become imperative for any asset tracking company looking to survive. IoT platforms in this space have to be able to aggregate location data, calculate alternative routes, monitor environmental factors, and assess weather predictions and relevant events - all to inform supply chain decisions that can improve a company’s bottom line.

The impact on the asset tracking and management industry is wide and varied. Data enrichment from sensors for diagnostics and predictive analysis for contingencies can impact and influence business operations through real-world engagements. For example, a major appliance manufacturer recently jumped into “smart” appliances and received ongoing reports of washing machines failing but they were unable to identify why. Enter location data: replayed Wi-Fi scans from the faulty devices determined that a part was failing above ~6000 feet in altitude and that was causing the overall machine failure. This discovery saved the manufacturer “millions” in operational, recall and repair costs.

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## USE CASES & SERVICES TO CONSIDER

Despite the breadth of industries that can benefit from IoT, there will be common needs for tools and services. There are multiple functional areas that platforms need to consider.

### Connecting Your Devices

IoT wouldn't be IoT without a network connection, but the infrastructure for connecting devices isn't as seamless as it is on today's desktop and mobile. Use cases and required areas of coverage will play a large role in your decision, but there is a growing array of available connectivity solutions. There are multiple players in Low-Power Wide-Area Networks (LPWAN) that offer battery-efficient, low-power solutions for the intermittent connectivity of small devices. Several of the many popular options to consider when starting your IoT implementation include:

#### Sigfox

Sigfox is a well-funded company whose goal is to become the global connectivity solution for IoT. While they have a low-cost solution available today, their ambitions are to own the entire infrastructure surrounding IoT implementations - ultimately by getting network operators to pay royalties on reselling its technology stack to customers. In other words, SigFox gives away the hardware that enables connectivity, but sells the software/network as a service (Source: [Link-Labs](#)). In some cases, Sigfox deploys the network and acts as the network operator; such as in France and the U.S. Signing on with them may seem like a simple all-inclusive solution, but one should consider coverage area and network ownership when selecting.

Basic alarm systems, location monitoring, and simple metering are just some examples of what might make sense for this network (Source: [Link-labs](#)).

## LoRa / LoRaWAN

LoRa is hailed as one of the best open-source, cost-efficient protocol options for long-distance connectivity. Unlike Sigfox, anyone can own the infrastructure, so there's less risk in using this solution in the long-term. Both Sigfox and LoRa can only transmit smaller payloads. Evaluate your use case in detail to determine if these solutions are appropriate for your project.

The best use cases for LoRa and Sigfox involves simple sensors that need to transmit data infrequently. For meters that update the reading, say once per hour, it may not be critical if some readings are missed, as long as some make it through (Source: [NickHunn](#)).

## LTE-Cat-M1 (eMTC or LTE-M) and LTE-Cat-NB1 (NB-IoT)

Both LTE-M and NB-IoT are evolutions of existing cellular LTE technology that adds lower power and network bandwidth options to network operator services. Because of this, these technologies will come as part of a regular infrastructure upgrade, so support requires virtually no setup. LTE's challenge may lie in higher costs, reminiscent of LTE networks that were created to accommodate larger data transmissions with larger power costs.

LTE for IoT has more than a few kinks to work out and has come under heavy criticism as a late effort by carriers to maintain control of network connectivity for all devices. However, the infrastructure has the longest history of connectivity and can be a safe bet for companies who are ready for massive deployments, with more frequent data transmission. Cell coverage may not be ubiquitous, so do your research into your areas of need.

## Data Analytics

The most important output of IoT is data, and lots of it. Vernon Turner, SVP of IoT from the technology research firm IDC, states, "It is approximated that the IoT industry will have to manage 44 zettabytes by 2020 and analytics and open data platforms will play a significant role in providing insights into this massive amount of data."

Collecting and interpreting data from IoT devices is still at a very early stage. McKinsey states, "most of the IoT data collected today are not used at all, and data that are used are not fully exploited. For instance, less than 1% of the data being generated by the 30,000 sensors on an offshore oil rig is currently used to make decisions." This leaves a significant amount of value capture and creation on the table that could have the potential to fundamentally change your organization's performance or business model.

There are three things that need to happen in order to change how companies think about data capture and analytics in an IoT environment:

- 1** Beta test smaller use cases to prove initial value in data capture and the potential return of improvements.
- 2** Turn to trusted analytics software partners that have experience in similar areas to provide commercial off-the-shelf (COTS) solutions to make it easier to begin to mine your data.
- 3** Evaluate available analytics offerings from IoT platforms and IoT cloud providers when performing a buy versus build evaluation.

Bottom line, even though the size and potential of IoT data is massive, start small with targeted use cases. Share the data with a diverse group of stakeholders, including business owners and analysts, to discover how to create value with IoT data.

## Predictive Maintenance

Predictive maintenance ( the ability to predict equipment failures before they happen), is perhaps the biggest area of opportunity for value creation within IoT. This will be revolutionary for many industries both in cost savings and in productivity. Previously, most asset intensive companies have used manual processes to maintain and repair their assets, using periodic scheduled maintenance as a means to catch failures before they occur. IoT provides a fundamental shift in how organizations think about maintaining assets by turning potential disasters into minor repairs or inspections.

A company at the forefront of predictive maintenance for industrial assets is Rockwell Automation, who were quoted in Microsoft's blog [Fueling the Oil and Gas Industry with IoT](#). Rockwell Automation is using Microsoft's IoT services to extend its business and provide managed monitoring and support for its products in the field. The company has put years of research into developing cloud-based solutions, using software, sensors and devices to predict equipment failures along the supply chain, track its performance in real time, and help refine designs and processes to prevent those failures in the future.

Rockwell has been helping Hilcorp Energy Company, an organization that has oil-drilling platforms operating 24 hours a day, year round to pull crude oil from beneath the ocean floor. Hilcorp recently upgraded its pumping equipment, but even small operational problems can have serious consequences. A single pump failing in an offshore rig can cost the company \$100,000 to \$300,000 per day in lost production. Rockwell Automation has connected the pumps' electrical variable speed drives to the cloud, so they can be monitored continuously from the company's command room hundreds of miles away. This connectivity provides real-time information on the equipment's performance and health — pressure, temperature, flow rates and dozens of other key performance indicators (KPIs). Engineers from Rockwell Automation are able to view KPIs from the sensors at any given time, ensuring equipment is performing within its specified parameters. The system can also be programmed to alert engineers of an abnormality the moment an issue is detected.

If Hilcorp is able to reduce their production losses from say, 10% to 5% each year using a daily rate of \$100,000, that's an estimated savings of \$1.8 million annually. This example brings home the real value in how predictive maintenance will impact a company's operations and their bottom line.

## Security

The risk of exposing an organization's data is one of the major challenges that IoT deployments face. Similar to the issues that mobile devices had in the early days, organizations are tasked with deploying and managing IoT devices as well as keeping them secure. In [Why IoT Security Is So Critical](#), TechCrunch summed up the challenge by noting that many IoT devices go through a one-time authentication process, which make them vulnerable to company network infiltration.

Further security is needed at key connection gateways to mitigate risk throughout a company's entire IoT system. This should not be considered a hindrance to an effective IoT deployment however, as many vendors have anticipated this concern. With so many risks associated with IoT there is an influx of security vendors that are building solutions to specifically tackle these challenges.

There are also questions concerning where to store data e.g. cloud vs. edge of network. Edge of network simply means the data is stored on the device where it was originated. Often times organizations need to have data reside locally so that they can make informed decisions in a remote setting in real-time, e.g. oil and gas remote wells. This is the opposite approach to sending everything to online storage for big data analysis and a central point of security.

The challenge is that many organizations will use a mix of both methods due to use case requirements, thus compounding the complexity of their deployments and security challenges.

## Location-based services

For many IoT solutions, having location as part of the data collection is just as critical as having time associated with each event. Considering that more than 50% of developers working on IoT solutions are thinking globally, many devices will require location awareness in order to complete their function and provide rich, contextual data. Whether it's used in tracking a fleet of assets, allowing secure access to devices in certain locations or predicting machine maintenance across multiple sites, location data can reveal correlations, patterns, trends, opportunities and risks that may not be readily apparent in all IoT use cases.

Many industries will rely on the ability to track high-value assets throughout their business processes. Industries directly impacted by IoT and location-based services include:

- Logistics & supply chain
- Healthcare
- Manufacturing
- Oil and gas

The ability to provide a solution that covers both indoor and outdoor environments through the asset's entire journey while minimizing power consumption will be a critical requirement of IoT location services.

For example, let's say a global logistics data company needed location awareness across partner trucks, planes, ships and trains for optimal delivery route analysis. Companies may expect that putting a dot on a map is fairly straightforward, however there are many challenges to actually executing this task. Many people look to GPS as the ultimate solution for providing a location solution. However, as with manufacturers of smartphones have discovered, GPS alone does not necessarily solve the problem. The challenges GPS faces include:

- Power consumption
- Time to first fix
- Indoor signal loss
- Urban canyon multi-path challenges
- Bill of Material chip costs

To overcome these challenges, the company used location services based on patented positioning technology and a comprehensive database of Wi-Fi networks, allowing for precise location in all locations where GNSS/GPS or Cell positioning falls short, such as in dense urban environments.

Choosing the right location partner allows companies to focus on their core competencies without having to worry if the location data they're using is correct or available. Since location services should be flexible enough to adapt to any new use case, evaluate partners' ability to address your specific location needs.

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## Conclusion

There is no machine, device, or industry that will not be effected by the IoT revolution, hence the new term 'The Internet of Everything.' Companies may expect a one-size-fits-all solution, but companies must approach deployment on a case-by-case basis. They must make difficult choices depending on the use case involved, but know that the insights and value derived from deployments will only increase with time.



**Skyhook**, a Liberty Broadband company, is a pioneer in location technology and intelligence. We strive for continuous innovation as evidenced by our 650+ patents and the fact that our technology provides the foundation for mobile location services in the global smartphone market. We provide our customers with real-time services and analytical insights via a combination of precise device location and actionable venues. Our products are built on the pillars of trust and respect for individual privacy.

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