## WB

### Business Rewired
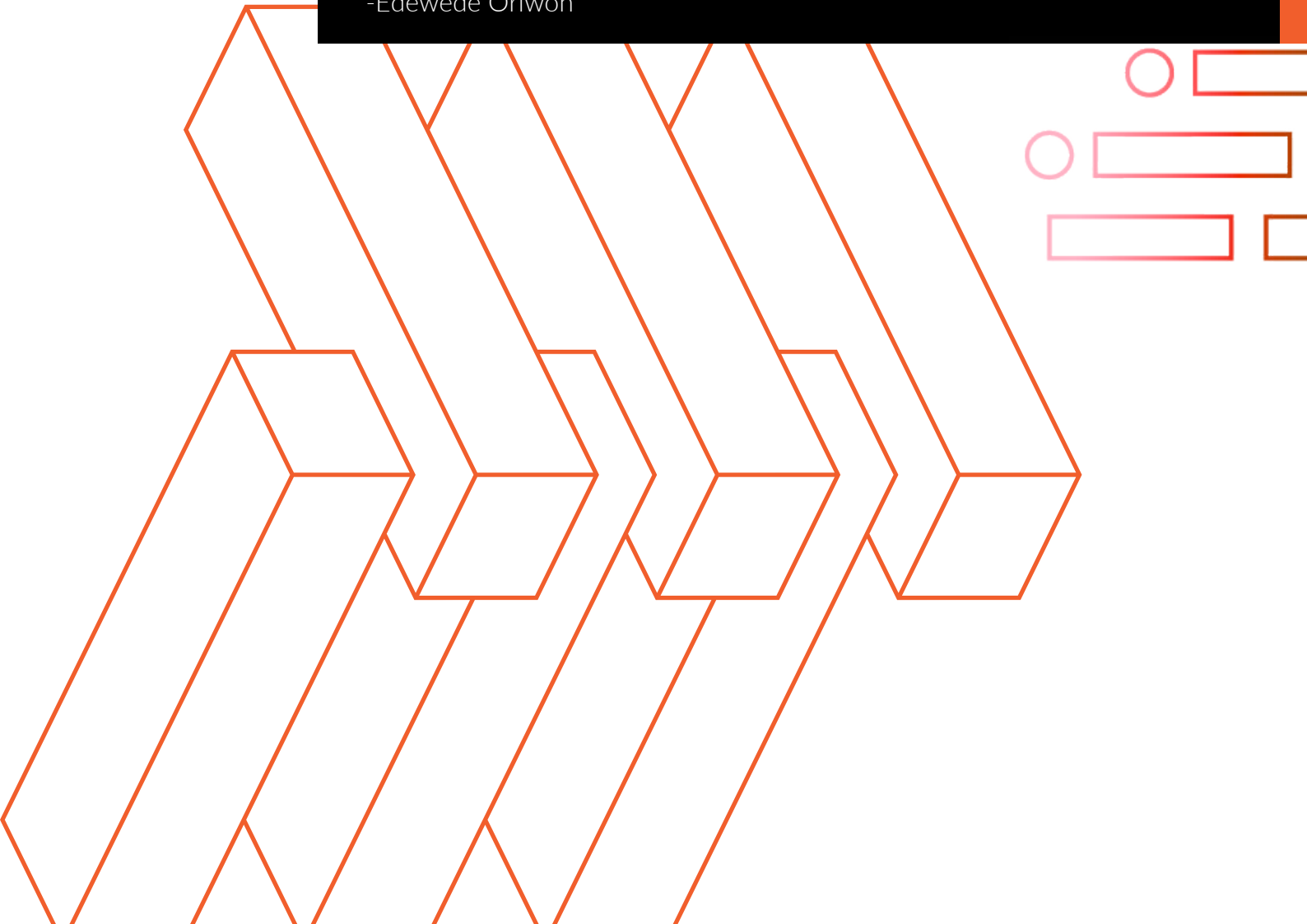
Innovation | Leadership | Strategy| Sustainablity | Ventures

# Introduction to the Internet of Things

*"The Internet of Things is not a concept; it is a net- work, the true technology-enabled 'Network of all Networks.'"*

-Edewede Oriwoh

# CONTENT

# INTRODUCTION TO THE INTERNET OF THINGS

Over the past five years, the term Internet of Things, or simply IoT, has been added to technology's list of acronyms. In simple terms, IoT refers to devices connected to the internet to transmit data. So, what are the origins of IoT and what is in store for the future? We will explore these ideas within this white paper.

## Google Search Interest of IoT

**Interest over Time Jan. 2012 – Feb. 20181**
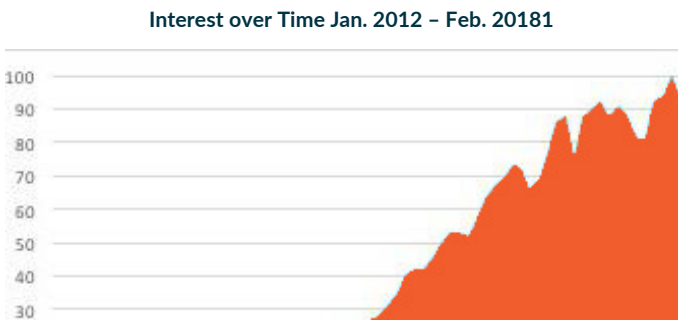


According to industry experts, by 2020, 10 billion+ new devices and connections will be added to the internet, which will increase the amount of IoT devices and connections to over 26.3 billion.2 Analysts estimate that this massive uptick will result in more than $6 trillion being spent on IoT products, solutions and integration services over the next five years. Regardless if a company is already selling IoT solutions, does not know what IoT is, or is thinking about how to break into the IoT market, there is a large opportunity to increase a company's revenue because IoT will touch every single industry in the next five years.

To better understand this opportunity, let's review the three core components of IoT that are all rapidly growing in functionality and vendor options.

- Hardware
- Connectivity
- Platforms & People

## HARDWARE

Any device that records data (location, temperature, motion, weight). This includes sensors, GPS fleet trackers, mHealth devices, and everything in between.

## CONNECTIVITY

A connection that can transmit data via cellular, wireline, satellite, WiFi, LoRa, electrical line or any other type of connectivity.

## PLATFORMS & PEOPLE

Sensors send data via connectivity to a management platform or person to analyze and act on the data. These platforms can simply record the data for future analysis or have rules built into them to have a real-time reaction (make a real-time decision).

All three components of IoT are experiencing a variety of options being introduced into the market. New devices, new connectivity options, and an endless number of platforms. As these new technologies and services come to market, every industry has the opportunity to leverage IoT to reduce cost, offer new services and expand market share or generate new revenue.

# THE THREE INDUSTRIES DRIVING GROWTH

According to the 2017 IDC report, the three driving global industries for IoT today are Manufacturing ($178 billion global), Transportation ($78 billion global) and Utilities ($69 billion global).3 These industries have the most IoT traction because of the positive ROI use cases.

## MANUFACTURING

Diagnostics and preventative maintenance reduces the cost of devices or machines breaking or incurring downtime by scheduling maintenance before a component of the device or machine fails.

## TRANSPORTATION

Fleet management and asset tracking enable route optimization, supply chain management and monitoring of mobile assets to streamline operations and manage conditions, a lost or stolen asset, and compliance requirements.

## UTILITIES

Power transmission lines and pipelines crisscross the United States and monitoring these assets would be extremely difficult without remote monitoring and control applications. These applications minimize the need for a "truck roll," a person or team physically going to a location, unless it is absolutely necessary.
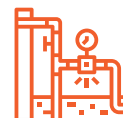
# CONNECTIVITY EVOLUTION

DEVELOPING NEW CATEGORIES

With the evolution of cellular technology and the widespread deployment of 4G LTE wireless networks, the data transmission rate has increased significantly and enabled one to live stream videos on all wireless carriers in the past couple years.

For most M2M applications, this communication speed is overkill. 4G LTE is great for the consumer, but to utilize these networks, M2M devices will need 4G LTE hardware which is more expensive than 2G or 3G modules. In response to this issue, wireless carriers adopted LTE Categories CAT 1, CAT M1 and NB IoT to have IoT devices utilize 4G LTE networks without the need for the cutting edge expensive hardware.

4G LTE is like the high speed lane of the highway and CAT 1, M1 and NB IoT would be comparable to a bike lane. The bike is much less expensive than a car, but still accomplishes the goal.

With the evolution of LTE, devices can be produced to the exact specs and requirements of each application. This greatly reduces the cost of IoT hardware, so previously cost neutral deployments will have a positive ROI. Additionally, the devices will be developed to minimize the amount of data sent in each message so the connectivity costs will be reduced.

## CAT 1

Delivers scalable performance and seamless mobility for high performance IoT use cases. Download peak of 10 Mpbs.

**IoT Gateways** **Connected Cars** **Smartphones** **Digital Signature**

## CAT M

Optimizes for the broadest range of IoT applications with high-reliability and low latencies. Download peak of 1 Mbps.

**Industrial Handshields** **Wearables** **Security Systems** **Health Monitors**

## NB IoT

Provides extreme optimization for low cost, low power, low throughput, delay-tolerant stationary IoT use cases. Download peak of 250 Kbps.

**Parking Meters** **Industrial Sensors** **Sensors** **Lighting/HVAC Controllers**

## CELLULAR & LPWAN

Cellular technology is used by wireless carriers in the US. They are known in the industry as Mobile Network Operators (M N O s).

Several companies create partnerships with these MNOs to offer cellular connectivity (voice, SMS, data). They simply repackage the cellular service and sell to consumers and companies. These companies are called MVNOs (Mobile Virtual Network Operators). They sell cellular service, but do not own the physical network infrastructure.

Examples of consumer MVNOs are Boost Mobile, Cricket, Project Fi and over a hundred more consumer facing companies. In the US, the main commercial MVNOs are KORE, Telit, ORB-COMM, Aeris and a handful of additional companies.

### MNO's

AT&T  verizon✓

Sprint  T··Mobile·

### MVNO's

aeris.  KORE

Telit  ORBCOMM

twilio  SIERRA WIRELESS

eseye

### International MVNO's

Telefónica  orange

vodafone  中国移动 China Mobile

### Global IoT Connection Forecast

IoT connections are dramatically increasing. The two largest increases in types of connectivity are Cellular IoT, which has a 27% CAGR (Compound Annual Growth Rate) from 2015 to 2021, and non-cellular IoT, which has a 22% CAGR from 2015 to 2021.4



| | 2016 | 2022 | CAGR |
|---|---|---|---|
| Wide-area IoT | 0.4 | 2.1 | 30% |
| Short-range IoT | 5.2 | 15.5 | 20% |
| PC/laptop/tablet | 1.6 | 1.7 | 0% |
| Mobile phones | 7.3 | 8.6 | 3% |
| Fixed phones | 1.4 | 1.3 | 0% |
| | 16 billion | 29 billion | |

As previously discussed, cellular evolution and how cellular connectivity is being refined by the introduction of CAT 1, CAT M, and NB IoT. These new classifications are part of the driving forces of Cellular IoT growth.

Low Power Wide Area Networks (LPWAN) are a component of the non-cellular IoT category. Aside from the new LTE categories, the most widely used LPWAN is LoRa. It is a low power, low bandwidth protocol that is being deployed for remote monitoring such as smart meters. A key aspect to these types of deployments is that the devices utilize very little power and can be powered for up to ten years.

LPWAN features include:

- **Long Range:** The end-nodes can be 6 miles from the gateway, depending on the technology.
- **Low Data Rate:** Less than 5kbps bits per second. Often only 20-256 bytes per message are sent.
- **Low Power Consumption:** A very long battery life, often between 5 and 10 years.

# HARDWARE AND PLATFORMS

To make IoT work wirelessly, devices need to be deployed to capture data. There are many types of products in the market and they are very often focused on a specific task. This will primarily be either collecting or sending the data. There are four types of connected devices and hardware that should be understood prior to looking at the use cases.

## MODULES

A module is a component of an IoT device that enables the device to transmit and/or receive wireless communications via cellular, LPWAN, satellites or additional radio frequencies. Devices that were previously not connected can have a wireless connectivity module added to them and, just like that, they are a connected device.

## SENSORS

A sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, pressure, or any one of many environmental phenomena. Sensors are typically inexpensive devices that connect to a gateway or hub to analyze or push the information to a platform.

## GATEWAYS

A gateway is a device that connects two networks using different protocols. For example, the door sensor communicates to a gateway that the door has opened, and the gateway then communicates to you that the door was opened. The sensor cannot communicate directly to the homeowner because it is not as sophisticated as the gateway, which will cost more money for this functionality.

## DEVICES

Devices can mean many things. As a rule of thumb, an IoT device should be able to both collect and transmit data to a platform. An example is a GPS device that tracks the location of a truck and transmits the location to the fleet management headquarters.

At a high level, an IoT platform is the support software that transforms the data collected from the hardware to an end-user application. IoT platforms typically handle ongoing management tasks and data visualization, which allow users to automate their environment. IoT platforms are often referred to as middleware solutions, which are the "plumbing" of IoT.

## Platforms

There are three main types of platforms, and we've ordered them here from least sophisticated to most sophisticated:

## DEVICE MANAGEMENT

These platforms focus on monitoring, troubleshooting, and providing administration for connected devices. Many hardware manufacturers will provide a platform to connect to their devices or multiple devices, which requires integrating device specific drivers into the platform.

## SUBSCRIBER MANAGEMENT

In the MNO & MVNO space, these platforms are trying to simplify connecting cellular M2M data, so you don't have to build the entire data infrastructure. Most MNOs & MVNOs offer a platform and these platforms may incorporate some aspects of device management.

## APPLICATION ENABLEMENT

Includes platforms that offer templates, modules, or widget frameworks in order to create end-user applications. These platforms can quickly turn data into either intelligence or action. Transforming data into actionable intelligence is where the value of IoT is derived.

# CELLULAR

Cellular connectivity is the type of wireless connectivity that everyone is familiar with because they use it with their cell phone. For a consumer, the cellular data plans are based typically on gigabytes (GB) of usage, but for an IoT commercial application, the plans are generally between 1 megabytes (MB) and 5 MB of use. A GB is 1024 MB so consumer plans use a lot more data by watching videos, using apps, and browsing websites. A commercial IoT device is very different because it might send a message that is only 10 bytes. Not 10 MBs, but 10 bytes. A MB has over a million bytes. So commercial IoT data requirements are very minimal as noted in these examples.

In contrast to LPWAN, cellular coverage can support applications that require large file transfers whereas LPWAN cannot support many applications due to the size of a message. For instance, time sensitive large file transfers may not be a feasible LPWAN application.

### Tractor Trailer
1mb - 5mb per month

### Redbox/Vending
1mb - 2mb per month

### Traffic Lights
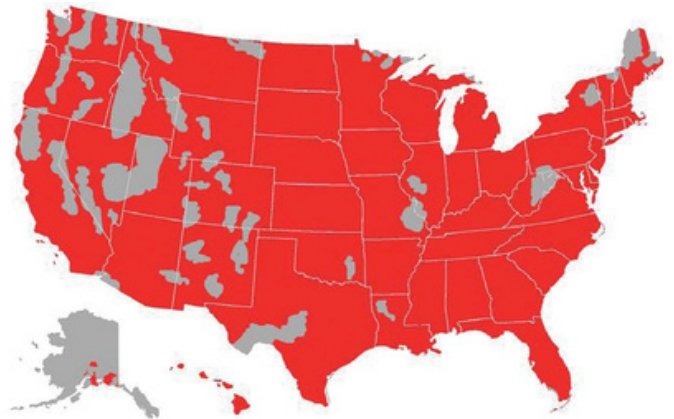1mb - 2mb per month
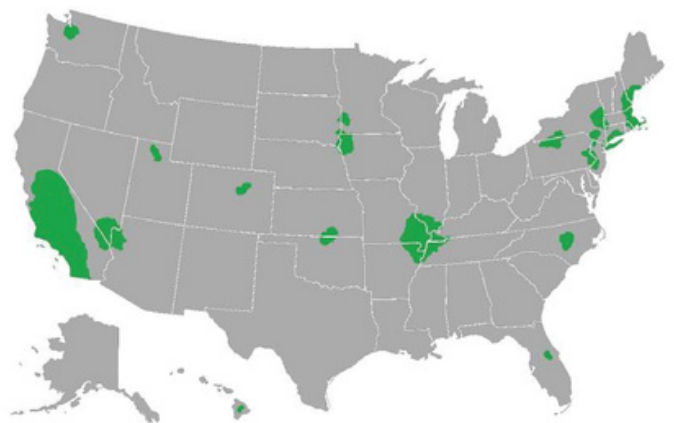
### Tank Monitor
< 1mb per month

## Standard Network Comparison

**Cellular Coverage Map**



**LPWAN Coverage Map**



The competitive advantage of cellular over other connectivity options is its coverage. These maps show the difference in coverage between a leader in the MNO space and a leading LPWAN provider. There is a stark difference. Satellites can provide even more coverage than cellular, but cellular is dramatically less expensive.

Since the coverage already exists, the ecosystem for hardware and software partners is already mature so no company needs to take on additional risk by utilizing a new technology that may have limitations that they will not know until it is in use.

The best use cases for cellular IoT are:

- Mobile assets such as transportation vehicles
- Connected medical devices that can monitor patients at home
- Deployments that can not rely on third party Wi-Fi such as vending machines
- Payment processing, security monitoring, and many more applications

## NON-CELLULAR

### LPWAN

LPWAN coverage is best suited for long-range applications with low bandwidth requirements.

Module pricing for LPWAN is $5 - $15 and the connectivity is typically between $1 per year per device and $1 per month per device.[5]

There are two main areas where LPWAN technologies are best suited:

- **Fixed, medium to high density connections in cities or buildings.** Examples include smart lighting controllers, distribution automation (smart grid), and campus or city-focused GPS asset tracking. There have been multiple city deployments of LPWAN that will be the foundation for Smart Cities in those cities.
- **Long life, battery powered applications when a long range is needed.** Examples include wide-area water metering, gas detectors, smart agriculture, and battery powered door locks and access control points.

### SATELLITE

Satellite connectivity can be separated into 3 categories: Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary orbit.

### LOW EARTH ORBIT (LEO)

LEO satellites orbit between 186 miles (300 km) and 1,243 miles (2,000 km). A low Earth orbit is the simplest and least expensive for satellite placement. It provides low communication latency, but satellites in LEO will not be visible from a given point on the Earth at all times.

### MEDIUM EARTH ORBIT (MEO)

MEO satellites orbit between 1,243 miles (2,000 km) and below geostationary orbit (altitude of 22,236 miles or 35,786 km). The most common use for satellites in this region is for navigation with the Global Positioning System (GPS) satellite constellation in MEO. The Global Positioning System (GPS) satellite constella- tion is MEO.

### GEOSTATIONARY ORBIT (GEO)

Follows a circular orbit 22, 236 miles (35,786 km) above the Earth's equator and following the direction of the Earth's rota- tion. An object in such an orbit has an orbital period equal to the Earth's rotational period and thus appears motionless to ground observers. Communications and weather satellites are often placed in geostationary orbits so that the satellite antennas (lo- cated on Earth) communicating with them do not have to rotate to track them, but can be pointed permanently at the position in the sky where the satellites are located.



### NON-CELLULAR

Satellite hardware and connectivity is typically much more expensive than all other options and pricing is highly dependent on the deployment. The primary use case for satellite connectivity is for connectivity in very remote locations.

| Remote | Cellular + Satellite | Maritime |
|---|---|---|

Assets that will be stationary in a remote location will solely rely on satellite connectivity. The satellite only application (low data rate such as a sensor or high data rate such as video) will determine the type of satellite connectivity provider that one uses. The LEO providers provide lower data rates and the geostationary provide higher data rates.

Assets that will travel in and out of remote location will utilize dual mode connectivity, which is cellular and satellite. Tractor trailers and shipping companies utilize dual-mode connectivity to track inventory across the ocean and over land. Dual-mode switches back and forth between wireless and satellite to help optimize cost efficiency (because satellite is expensive) and reduce gaps in data and IoT connectivity.

BLUETOOTH
Bluetooth communication is a global short-range wireless communication protocol typically used for device-to-device file transfers, wireless speakers, and wireless headsets. BLE is a version of Bluetooth designed for lower-powered devices that use less data. To conserve power, BLE remains in sleep mode except when a connection is initiated. This makes it ideal for wearable fitness trackers and health monitors.

Bluetooth hardware is embedded in a device and is relatively inexpensive due to its maturity in the market. The connectivity is free since it is a device-to-device protocol that does not rely on a network.

W i- Fi
Wi-Fi is ubiquitous for consumers to connect their smartphones to the internet. For IoT, Wi-Fi connectivity is ideal for centrally located connectivity in a home or commercial building. The consumer and commercial use cases are typically for devices that would stay connected to an electrical source. This could include refrigerators, thermostats or surveillance cameras. If a person or company is already paying for the WiFi, then the connectivity is essentially free.

Standardization organizations are developing Wi-Fi features aimed specifically at IoT to simplify connectivity, extend range, operate at low power and provide location information.

# CONNECTIVITY COMPARISON

## Connectivity Type Recap

### CELLULAR
Easy, Everywhere

Cellular connectivity is the easiest communication technology to rollout because it is a mature technology, ubiquitous in the US (and the world), and very cost effective.

### Wi-Fi
Stationary, High Data Rate

Wi-Fi is ideal for in-building coverage and can provide higher data rates with greater reliability than the other options.

### LPWAN
Stationary, Low Data Rate

Low Power Wide Area Networks primary use case is for stationary assets with low data requirements. These networks are limited in geography and the communication technologies are in their early stages of deployment today.

### BLUETOOTH
Personal, Device-to-Device

Bluetooth connectivity is an easy, mature way to connect devices to other nearby devices and is applicable to consumer driven devices that don't want to have a monthly connectivity fee.

### SATELLITE
Remote Locations

Satellite communications is expensive and only cost effective for remote locations or as a backup for cellular connectivity.

# USE CASES

## HVAC Monitoring

## Internet Backup

**HVAC Monitoring** is a commonly applied IoT use case for homes and buildings to confirm that the machines are working properly.

- **Hardware:** A monitoring device that can be connected to or built in to the HVAC.
  - **Connectivity:** Primarily wired, Wi-Fi or cellular. This will be dependent on the setup of the location, which connectivity will be the most cost effective, and who is monitoring these HVACs.For this example,wewillutilize cellular.
- **Platform:** Many monitoring tools that would automatically alert a person if the HVAC malfunctioned.

If an HVAC malfunctioned, the monitoring device or component within the HVAC would communicate to the platform via cellular connectivity that could then dispatch a repairman. The notification to the repairman could be via cellular or other messaging services.

**Retail Locations** need to process payments for their business so many retailers purchase internet backup devices to ensure that they will be able to process payments when their internet goes down.

- **Hardware:** A POS register that connects via Wi-Fi to a gateway and data is then transmitted via a cellular network.
- **Connectivity:** A combination of Wi-Fi and cellular.
- **Platform:** Not as relevant since the connectivity is simply directing the payment request to a credit card company wirelessly rather than the wired internet connection that has f aile d .

High volume retailers and grocery stores require this type of redundancy to ensure payment processing.

# USE CASES

## Fleet Management



## Digital Signage
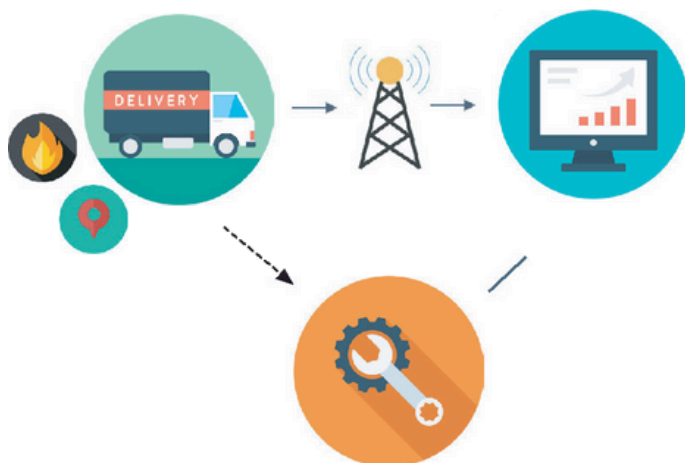


**Fleet Management** is another common application. This is typically used for tractor trailers, but could be applied for bike sharing services such as Citibike, car sharing services such as Zipcar, buses or any vehicle. Fleet management typically is focused on route optimization, monitoring and preventative maintenance. We will look at it with regard to preventative maintenance since it is a driving force behind many IoT deployments.

In this scenario, assume the engine is overheating.

- **Hardware:** Typically, wired into the truck to access its onboard diagnostics system.
- **Connectivity:** Primarily cellular and may have satellite as a backup, which is dependent on the budget of the fleet man - agement company.
- **Platform:** Many available to monitor the diagnostics of a vehicle and alerting a person of a problem.

The next step of to fixing an auto problem is finding an auto repair shop, which is manual, but will still be able to fix the problem before the overheating causes a greater mechanical failure.

**Digital Signage** is a growing market within IoT since it cuts costs of updating signs, eliminates printing, enables global advertising from one computer and enables programmatic advertising. This is a more simplified use case than the previous ones, but it may have a more positive ROI.

In this example, the marketing team is simply pushing the advertisement to the digital signs.

- **Hardware:** Typically a device that is connected to the sign because the device may require a large amount of storage space and computing power.
- **Connectivity:** Primarily cellular due to the large data files and ubiquitous coverage. In building signs may rely on a private Wi-Fi network.
- **Platform:** Different file transfer tools will send the files over time vs. one file. This will optimize the cost of connectivity.

Digital Signage is part of the general movement for technology to reduce or eliminate the need for paper.

## VALUE OF IoT

With many use cases in the market, every company should be thinking about IoT and how to deploy or develop an IoT solution that creates real value for their company and customers. As we have mentioned throughout this white paper, the cost of IoT devices and connectivity has decreased recently and will continue to decrease due to competition and the new LTE standards.

For connectivity, costs have significantly decreased due to competition. With hardware and cellular connectivity decreasing, these two components of an IoT solution are in a race to the bottom.

Cellular modules previously cost $40 plus because the modules were focused on high data rate requirements which support con- sumer activities such as video. Now, IoT module costs can range between $5 - $20 depending on the technology:

## IN SUMMARY...

- Cellular connected devices will increase over twenty percent every year for the foreseeable future.
- The hardware and connectivity cost for these devices will continue to decrease over time.
- Cellular connectivity has a superior advantage in the market because it is ubiquitous, a mature technology, and cost effective.
- LPWAN are effective in stationary, low data applications where there is coverage.
- Satellite connectivity is best suited for remote locations or as a backup to cellular, but it is the most expensive option.

The real value in IoT will stem from actionable intelligence gained from IoT data. Point-to-point solutions (fleet tracking, tank monitoring) are providing clear cut positive ROIs right now so many companies are deploying these, but there are still a lot of companies that have not scratched the surface. It's time to dive in and explore the endless amount of IoT opportunities for your company to capture, analyze, and act on IoT intelligence.