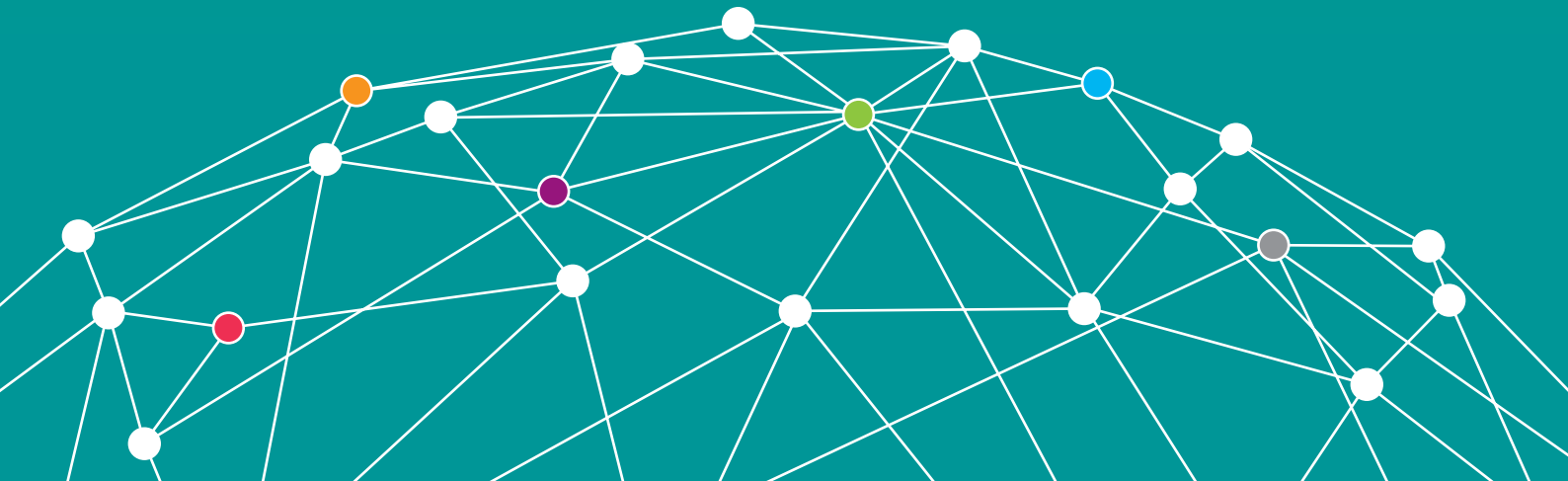# IHS Markit™

IoT trend watch 2018

What's inside

The four foundational phases
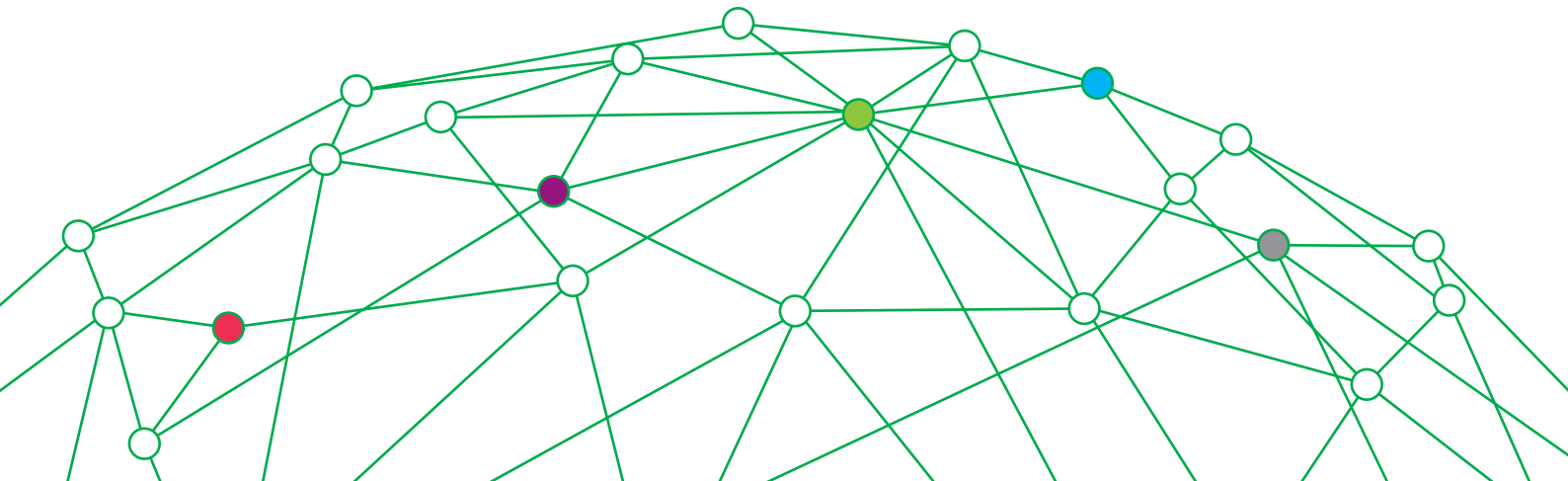of the IoT movement

Connect   Collect   Compute   Create

The IoT
defined

Our IoT
team

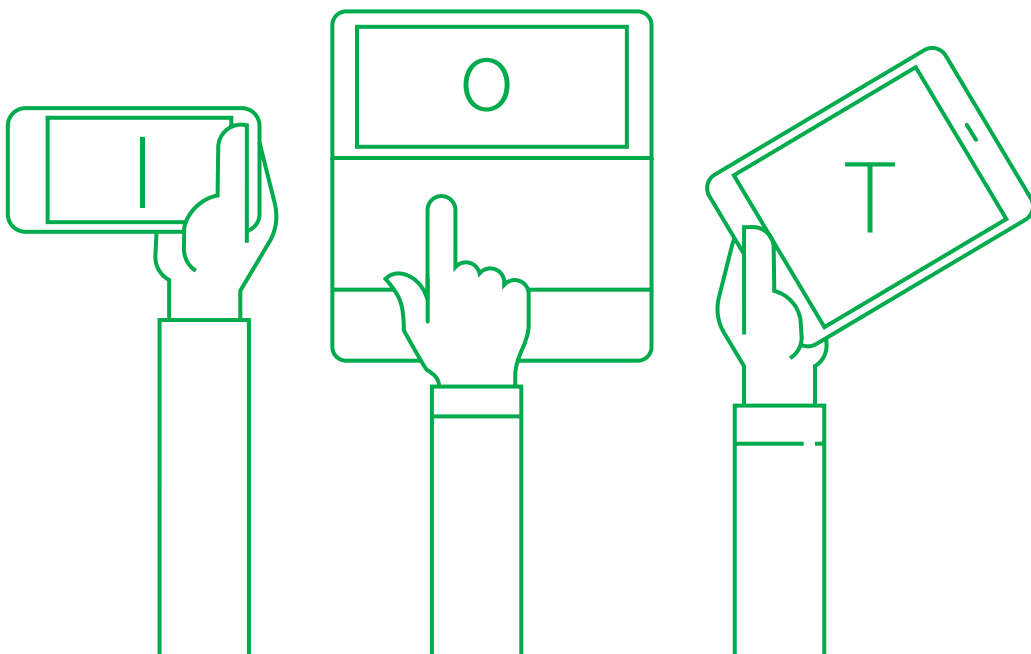IoT-connected
devices: 2018

Find out
more

What exactly is the IoT?

The Internet of Things, or "IoT," is not a device or even a technology. Rather, it's a conceptual framework, driven by the idea of embedding connectivity and intelligence across a wide range of devices.

IHS Markit defines an IoT device as having some form of embedded connectivity (wired or wireless), which allows it to connect directly to the internet or to another IP-addressable device. These devices can include a range of sensors, as well as some type of user interface. However, neither a sensor nor a user interface is required.

The ability to collect vast amounts of data in near-real time from a broad range of intelligent connected devices is the foundation of the IoT. This data can then be accessed directly, or via the cloud, and unique value propositions can be created through the application of complex analytics and big data techniques. In this way, the IoT can, and will, be used to create complex information systems that are greater than the sum of the individual components.
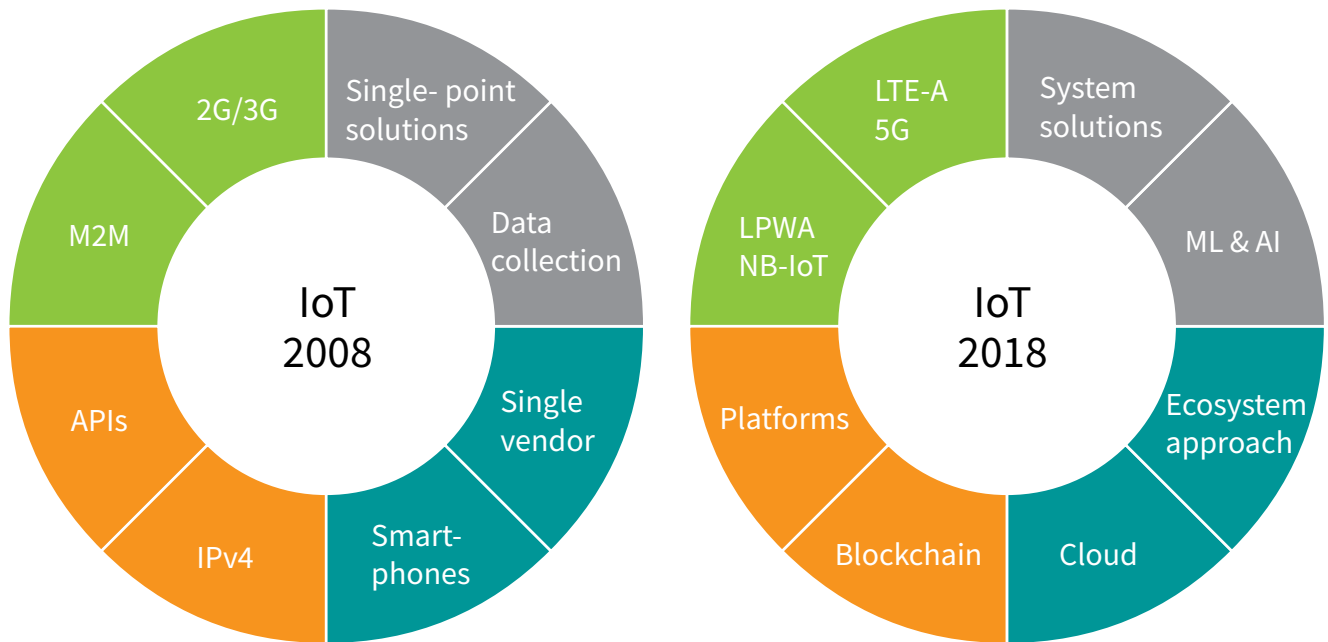
What are the four foundational pillars of IoT?

IHS Markit has identified four foundational, interconnected pillars at the core of the IoT movement: **connect, collect, compute**, and **create.** The entire IoT is built upon these four innovational pillars.

– New **connections** of devices and information

– Enhanced **collection** of data that grows from the connections of devices and information

– Advanced **computation** that transforms collected data into new possibilities

– Unique **creation** of new interactions, business models, and solutions

Connect

2021:
20 billon
Connectivity IC
Shipments

- Cellular
- WILAN & Bluetooth Classic
- Low Power Wireless
- Wired

New 5G and NB-IoT capabilities shift demand for celluar activity

Collect

Lotion/Oil

Sweat

Condensation

Emerging biometrics sensing technologies provide more convenient and stronger security

Compute

Platform (PaaS)
$10.7B

Infrastructure (IaaS)
$48.2B

Software (SaaS)
$54.8B

2016 Global Revenue

Cloud and XaaS driving new business models and cost efficiencies

Create

13%

25%

62%

2017

Google Assistant
Amazon Alexa
Other

23%

43%

2020

34%

Artificial Intelligence drives Google's dominance in digital assistant market

What key trends are driving the IoT in 2018 and beyond?

The IoT is not a new phenomenon, but increasing numbers of devices are getting connected and becoming smarter.

IoT 2008

- Single- point solutions
- Data collection
- Single vendor
- Smart-phones
- IPv4
- APIs
- M2M
- 2G/3G

IoT 2018

- System solutions
- ML & AI
- Ecosystem approach
- Cloud
- Blockchain
- Platforms
- LPWA NB-IoT
- LTE-A 5G

Key IoT drivers

Innovation and competitiveness
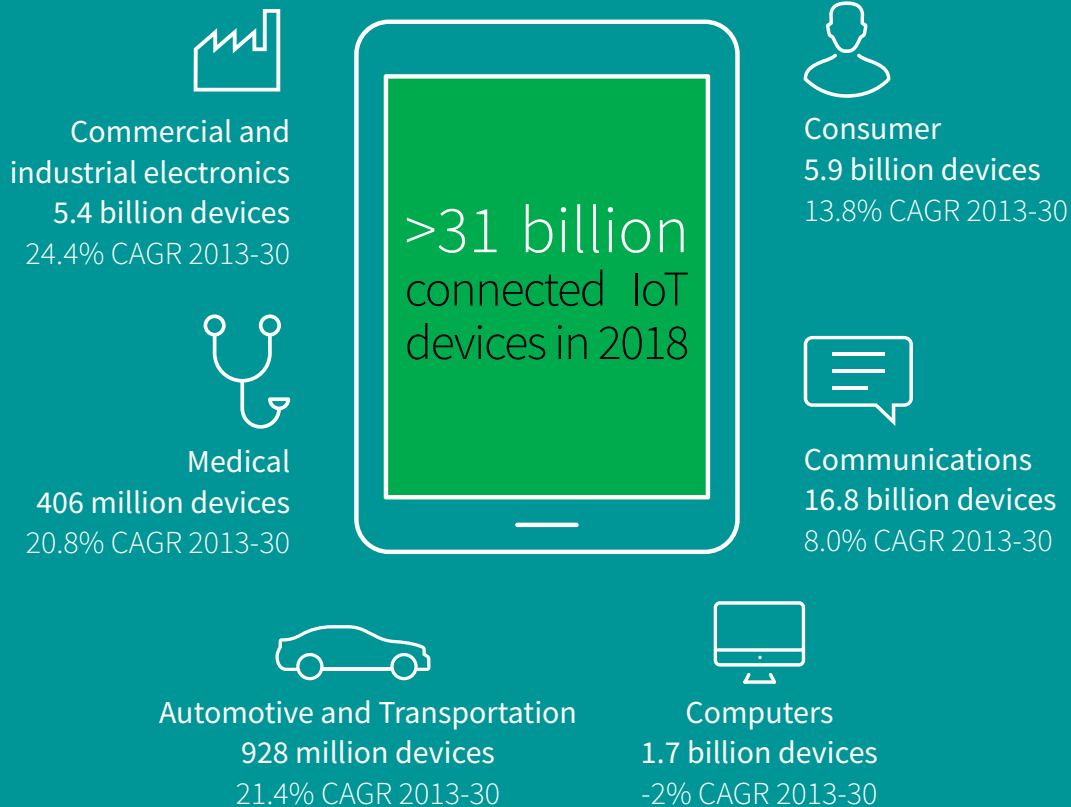
Business models

Standardization and security

Wireless technology innovation and optimization

Connect

Connections are the foundational component of the IoT. The IoT is about embedding connectivity and processing capabilities into devices all around us.

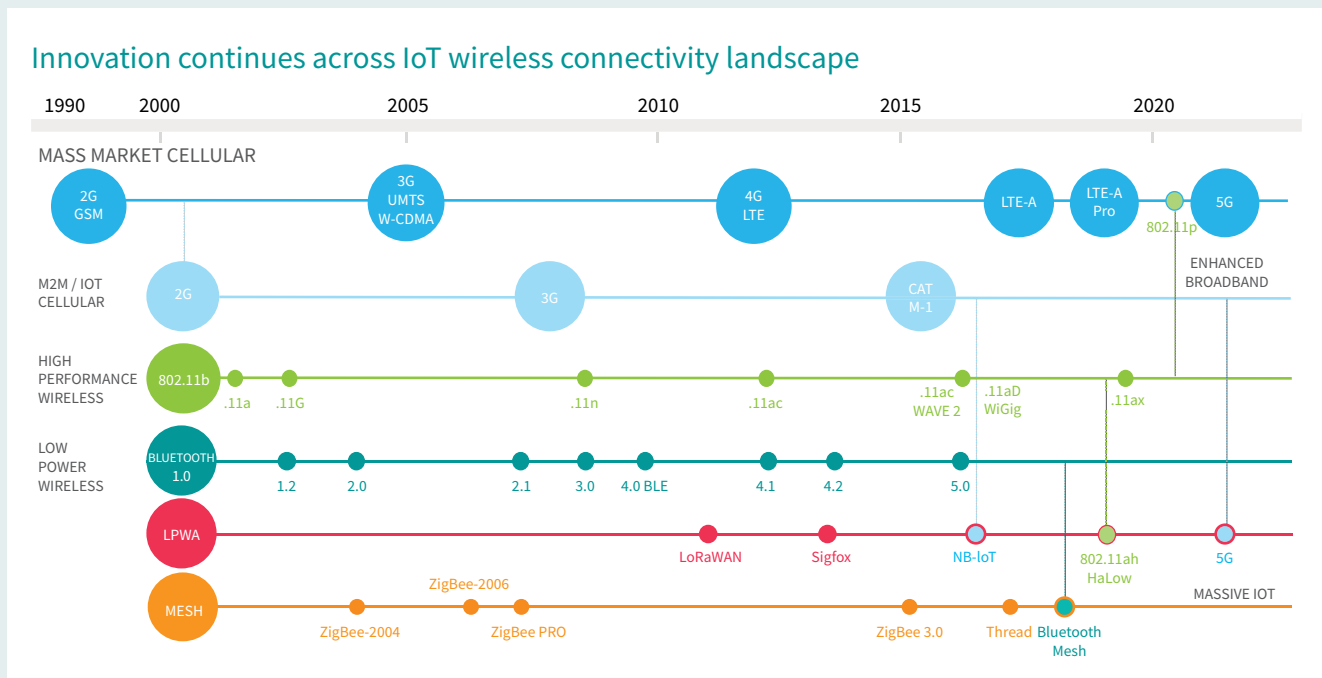## How many IoT devices will be connected globally in 2018?

The commercial and industrial sector, driven by building automation, industrial automation, and lighting, will account for nearly 50% of new connected devices between 2018 and 2030.

Commercial and industrial electronics
5.4 billion devices
24.4% CAGR 2013-30

Medical
406 million devices
20.8% CAGR 2013-30

>31 billion
connected IoT devices in 2018

Consumer
5.9 billion devices
13.8% CAGR 2013-30

Communications
16.8 billion devices
8.0% CAGR 2013-30

Automotive and Transportation
928 million devices
21.4% CAGR 2013-30

Computers
1.7 billion devices
-2% CAGR 2013-30

Innovation and competitiveness

Connectivity standards proliferate ahead of IoT opportunity

While decades of consolidation and activity have resulted in market stability and de facto standards for PAN and LAN solutions, the IoT opportunity lying ahead of the market has attracted numerous duplicative and overlapping wireless solutions. Some solutions are derivatives of existing standards (Bluetooth, Wi-Fi and LTE), while others are new entrants (LoRa, Sigfox and Thread). Standards consolidation lies ahead, but confusion and fragmentation will dominate in the near term.

Innovation continues across IoT wireless connectivity landscape

| 1990 | 2000 | | 2005 | | 2010 | | 2015 | | 2020 | |

MASS MARKET CELLULAR

2G GSM · 3G UMTS W-CDMA · 4G LTE · LTE-A · LTE-A Pro · 802.11p · 5G

ENHANCED BROADBAND

M2M / IOT CELLULAR

2G · 3G · CAT M-1

HIGH PERFORMANCE WIRELESS

802.11b · .11a · .11G · .11n · .11ac · .11ac WAVE 2 · .11aD WiGig · .11ax

LOW POWER WIRELESS

BLUETOOTH 1.0 · 1.2 · 2.0 · 2.1 · 3.0 · 4.0 BLE · 4.1 · 4.2 · 5.0

LPWA

LoRaWAN · Sigfox · NB-IoT · 802.11ah HaLow · 5G

MASSIVE IOT

MESH

ZigBee-2004 · ZigBee-2006 · ZigBee PRO · ZigBee 3.0 · Thread · Bluetooth Mesh

Business models

5G was developed to address new opportunities across the IoT

5G builds upon earlier investments in M2M and traditional IoT applications to enable significant increases in economies of scale that drive adoption and utilization across all sectors of industry. Improved low power requirements, the ability to operate on licensed and unlicensed spectrum, and better coverage will all drive significantly lower costs across the massive Internet of Things.

Traditional cellular IoT challenges

Industry fragmentation

Complexity: technology and business

Technology not fit for purpose

5G

New cellular IoT opportunities*

Massive IoT
– Cheaper
– 10+ year battery life
– 100K devices / cell
– Deep coverage

Mission-critical IoT
– Ultra-low latency
– High reliability
– Immediate availability

Smart Cities

Smart Agriculture

Process Automation

Autonomous vehicles

*Note: a few examples among many

6

Standardization and security

Cybersecurity has emerged as a leading concern for IoT adopters

IoT deployments face critical cybersecurity risks because:

- There are potentially many more IoT devices to secure compared to traditional IT infrastructure devices.

- IoT devices can create a complex management environment, with diverse technology profiles, processing capabilities, use-cases, and physical locations.

- IoT devices can be embedded into systems that can affect physical health and safety, in addition to traditional communications or computing systems.

More things to attack – greater potential for harm
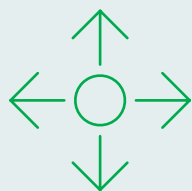
Growing attack surface
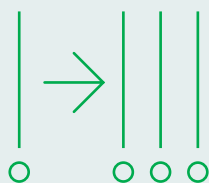
Increased risk to health and safety

Necessity for a "defense in depth" – not perimeter-based

Remote device

Network

Cloud/application

IoT cybersecurity threat examples

- **DDoS** - Mirai botnet showed that a vast number of consumer-grade IoT devices lack adequate security, and they could be used as part of a botnet attack

- **Virus/worm** – Stuxnet demonstrated that viruses can be installed deep inside even the most secure industrial facilities to disrupt and destroy operations

- **Hacking** - Jeep Cherokee "white hat" exploit painted a frightening picture of how vehicles in motion could be compromised remotely to disastrous effect for occupants

Wireless technology innovation

MuLTEFire and CBRS create private LTE opportunities

– Private LTE, enabled by licensed spectrum, has primarily been adopted by the public safety sector.

– Neither CBRS nor MuLTEfire require an "anchor" in licensed spectrum, which makes it much more practical for enterprises outside the public safety space to deploy their own private LTE networks.

– CBRS and MuLTEfire are both targeting use-cases where LTE's strengths as a 3GPP-standard technology, with strong security credentials, enhanced coverage and capacity, as well as global scale, can be leveraged in private networks, ranging from campus connectivity to remote pipeline monitoring.

– The first MuLTEfire trials will occur in 2018, following the publication of Release 1.0 specifications in 2017. In the USA, the FCC's final CBRS rules are set to release in 2018.

– The CBRS and MuLTEfire Alliances and their growing base of members will drive ecosystem development in 2018.

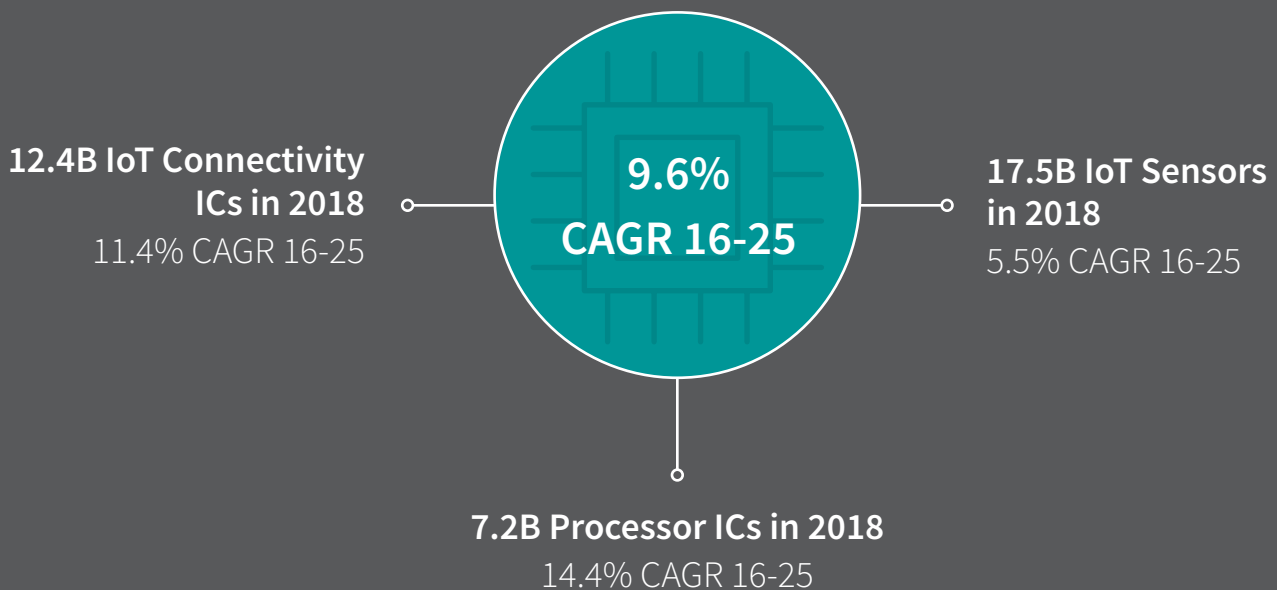| Private/hybrid LTE eNodeBs – shipments by application area (thousand units)								
	2015	2016	2017	2018	2019	2020	2021	CAGR 16-21
Public Safety	3.9	6.2	9.2	16.4	22.8	26.6	30.2	37%
Transport	0.7	1.0	1.3	1.5	1.7	2.0	2.5	19%
Industrial	0.4	0.6	0.7	0.9	1.1	1.4	1.6	24%
Utilities	0.1	0.1	0.2	0.4	0.5	0.6	0.7	40%
Others	0.8	1.1	1.3	1.5	1.7	2.3	2.6	19%
Total	5.9	9.0	12.7	20.6	27.8	32.9	37.6	33%

Collect

Once connected, adding sensors and storage to devices allows for unprecedented collection of data and information about the physical environment.

How many IoT semiconductors will ship in 2018?

Over 37 billion IoT semiconductors will be sold in 2018 in the sensors, processors, and connectivity categories alone. Over 90% of those semiconductors will be used in the communications, consumer, and industrial segments.

12.4B IoT Connectivity ICs in 2018
11.4% CAGR 16-25

9.6% CAGR 16-25

17.5B IoT Sensors in 2018
5.5% CAGR 16-25

7.2B Processor ICs in 2018
14.4% CAGR 16-25

Innovation and competitiveness

Home speakers leveraging innovation of MEMs microphone sensors

Demand for increased performance in the MEMs microphone market has been coming with a premium on price, unlike other sensors. The microphone ASP has been stable while the price of the accelerometers, gyroscopes and pressure sensors have plunged. Microphones, smart speakers, and remote controls dominate the fragmented MEMs IoT market. Amazon, the primary driver of adoption in the market, uses MEMs microphones as a key competitive advantage.
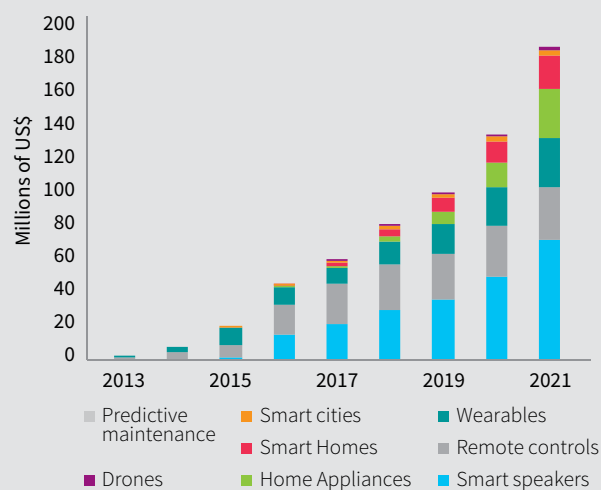
Amazon has become a heavy consumer of MEMs microphones

– About 45% of IoT market in value in 2016

– Became largest MEMS microphone buyer (ahead of HP) outside the handset segment in 2016

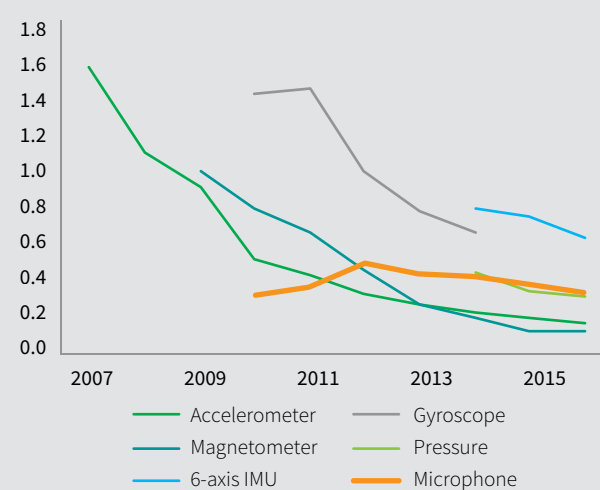With Alexa, Amazon takes natural speech recognition/voice command to the next level

– Not only on own hardware

– Pushes Alexa to as many connected devices as possible—in homes, in cars, etc.

– Natural voice command functionality boosts online sales

MEMS microphone shipments in IoT by application

Legend:
- Predictive maintenance
- Smart Homes
- Drones
- Smart cities
- Home Appliances
- Wearables
- Remote controls
- Smart speakers

Source: IHS Markit

Sensor ASP in US$ for iPhone

Legend:
- Accelerometer
- Magnetometer
- 6-axis IMU
- Gyroscope
- Pressure
- Microphone

Source: IHS Markit

Business models

This is the first wave of IoT data monetization. As the solutions become more sophisticated, so do the development costs. This creates an opportunity for IoT platform providers to focus on data exchange and data management offerings to reduce the complexity, cost, and risk for developers.

Vibration sensor component
$100 to $400
Meggitt, PCB…

$

Portable analyzer + 1 sensor: $20k
Or

Wireless vibration transmitter + 2 sensors: $6k
Emerson, GE…

$ $ $

Predictive maintenance service

Software: typically $150k to $300k per customer

Cloud-based service typically $40k to $60k per plant per year
GE Predix, Azima, Emerson…

Standardization and security

Collaboration, standardization and legislation are critical to ensure an end-to-end secure solution in the automotive Industry

Increasing volumes of connected devices will entail increased threats to privacy, safety, and information security. A hardware-based "root of trust" is the gold standard for ensuring that remote connected devices can be used in IoT applications securely and in a trusted manner. Significant work is happening to provide embedded technology that can serve as a root of trust for a typical IoT device profile with processing power, size, energy consumption, and cost constraints.

Trusted Platform Modules (TPM) and Trusted Network Connection (TNC) are among the key efforts to ensure embedded device security. These technologies have been developed by the Trusted Computing Group (TCG) industry consortium and standardized as ISO/IEC 11889.

As IoT devices become smarter and more connected, many vendors are beginning to push over-the-air updates to these devices. To ensure security, the number of devices using TPM and TNC protocols are growing, much like we observed in the PC market.

– TPM specification describes scenarios of using modules for proving "an Electronic Control Unit (ECU) identity, reporting the software in use, and remote deployment of maintenance updates."

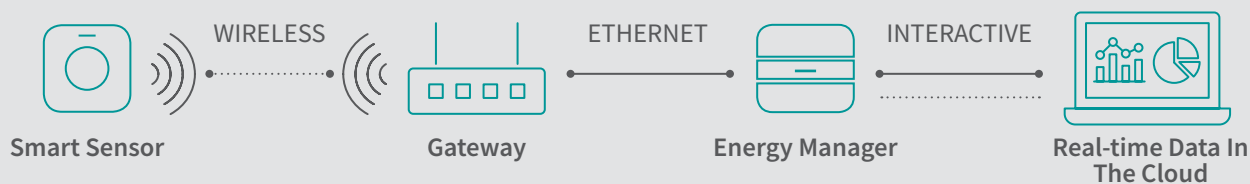| Secured input - output	Cryptographic processor	Persistent memory
	Random number generator	Endorsement Key (EK)
		Storage Root Key (SRK)
	RSA key generator	Versatile memory
	SHA-1 hash generator	Platform Configuration Registers (PCR)
		Attestation Identity keys (AIK)
	Encryption-decryption-signature engine	Storage keys

Wireless technology innovation

Connected lighting becomes platform for sensor deployment for IoT services in smart buildings

Some of the best and clearest examples of ROI are found in energy savings in smart office buildings. Large companies with several offices that have subscribed to connected sensor-based energy management services report that they are saving millions of US dollars on their energy and lighting bills. These rely on a combination of motion detectors (PIR sensors) and temperature and ambient light sensors.

The idea of using connected LED fixtures as an IoT platform in smart offices offers many compelling advantages:

– It takes advantage of available power supplies and connectivity.

– It is a scalable platform in term of services: these companies started with offering energy and lighting management. They expanded their services toward space optimization and management, security, etc.

– It is scalable in terms of sensors.

  – Today the smart fixture includes Passive Infrared (PIR) motion detectors, temperature sensors, and ambient light sensors.

  – In some cases, these start to also include Bluetooth beacons for logistic applications and color sensors (to enhance productivity of workers).

  – In the future, we expect Time of Flight sensors to be added for more accurate presence detection and people counting. CO2 sensors for worker productivity in peripheral devices could also be added (not in light fixture but taking advantage of connectivity and cloud).

– An example of using connected LED fixtures as an IoT platform in smart offices led to very attractive business models created by startups EnLighted and Digital Lumens. For instance, EnLighted offers some contracts without upfront installation fees, and in some cases, EnLighted is paying itself on the savings with zero risk to the customer.

WIRELESS   ETHERNET   INTERACTIVE

Smart Sensor   **Gateway**   **Energy Manager**   **Real-time Data In The Cloud**

Compute

Computing, processing, and analyzing the volume of data generated by IoT devices requires both edge processing and aggregating to be stored as part of big data solutions.

What level of growth will be driven from the shift toward service-based models in the Cloud?

As the number of internet-connected devices grows, there will be a significant increase in the amount of data created and stored, in addition to the real-time processing required to support these devices. Cloud service providers are well positioned to meet this demand, due to their quick, scalable, and efficient data centers. Cloud service providers are offering multiple data center services to enterprises as a cost-effective solution for massive and rapid digital transformation.

Infrastructure as a Service (IaaS)
21.2% CAGR 16-21

27.6%
CAGR 16-21
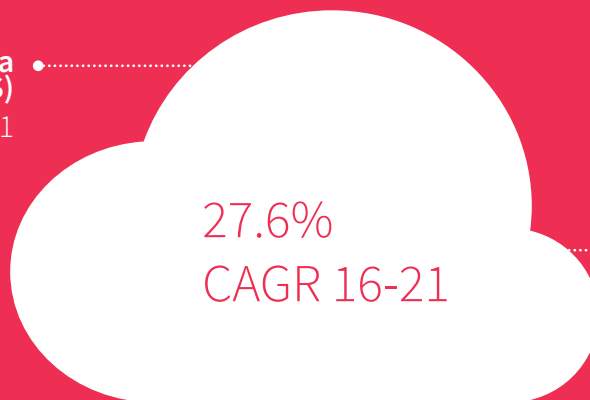
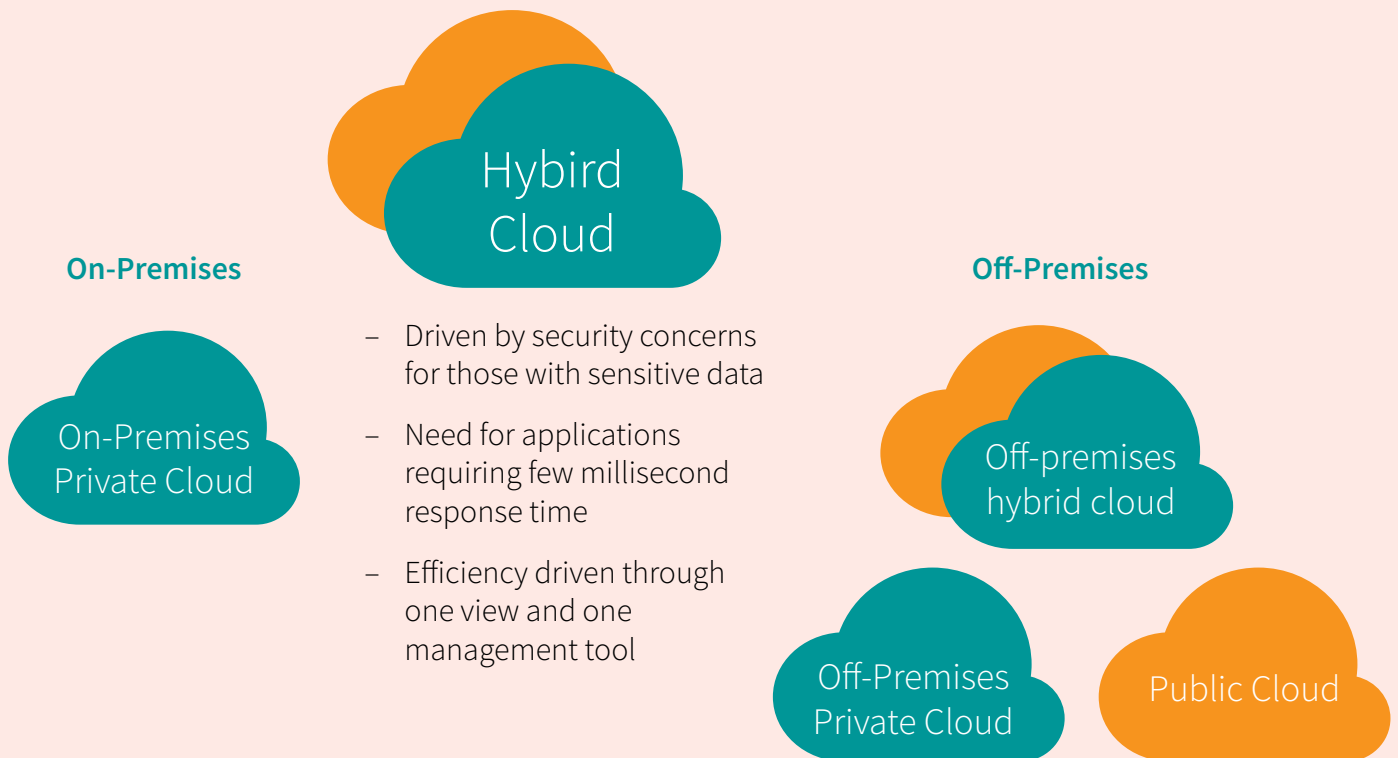**Cloud as a Service (CaaS)**
39.2% CAGR 16-21

Platform as a Service (PaaS)
37.9% CAGR 16-21

Innovation and competitiveness

Enterprises leverage location of data as a competitive advantage

Not all enterprises are embracing the cloud. Security remains a top concern for many enterprises and is inhibiting those that deal with sensitive data. Additionally, certain low-latency applications are not best served by cloud service providers.

While most applications don't require the few millisecond response time needed from an in-house data center, those that do are often not close enough to centralized cloud data centers to comply with this need. For these reasons, a hybrid approach to cloud and data center management is taking hold. This means that more companies are employing both on-premises data centers and off-premises cloud services to manage their IT.

On-Premises

Hybird Cloud

On-Premises Private Cloud

– Driven by security concerns for those with sensitive data

– Need for applications requiring few millisecond response time

– Efficiency driven through one view and one management tool

Off-Premises

Off-premises hybrid cloud

Off-Premises Private Cloud

Public Cloud

15

Business models

Cellular IoT gateways will be integral to edge computing deployments

- Cellular IoT gateways facilitate WAN connectivity in a range of traditionally unconnected machines and equipment, from commuter buses to oil pipelines.

- Gateways can give enterprises greater visibility into the performance of their remote assets and deliver connectivity to enterprises' own customers. This can enable enterprises to reduce unnecessary truck roll costs and provide a better experience to their own customers.

- Fierce competition in the fragmented cellular IoT vendor landscape is contributing to robust shipment growth of over 20% year-on-year. Vendors range from traditional incumbents like Sierra Wireless, to major IT players like Cisco, to industrialists such as Lantronix, and to enterprise specialists such as Cradlepoint.

- 2018 will see an increasing focus on compute capabilities and enhanced security for cellular IoT gateways, as they become central to the push for edge computing in IoT deployments.

Cellular IoT gateway unit shipment and revenue forecast summary, global market, 2014 - 2021

Source: IHS Markit
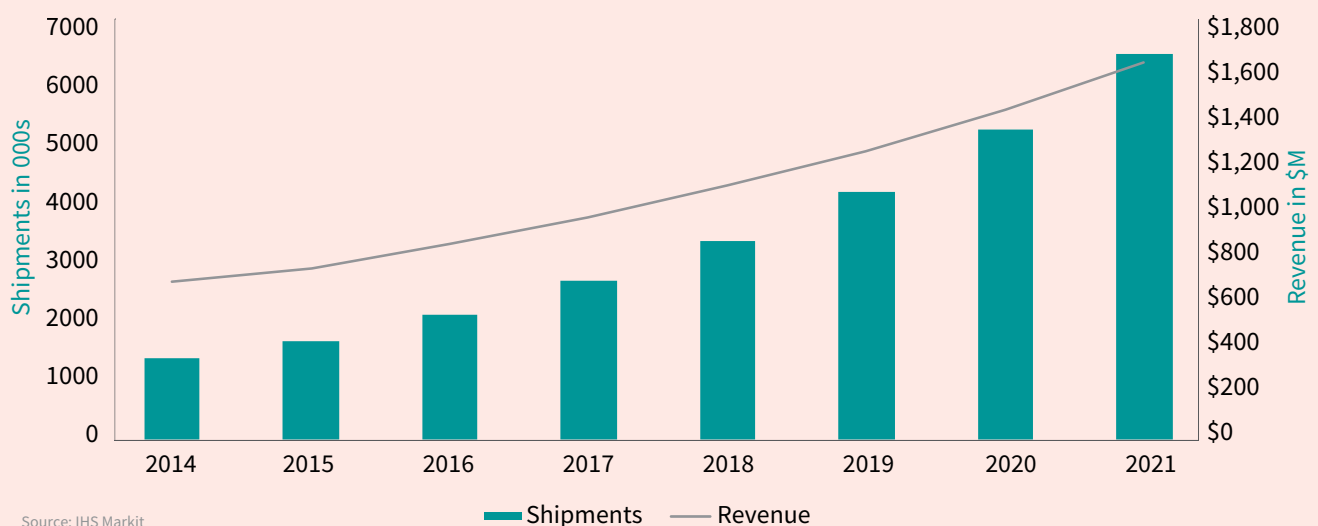
Standardization and security

Despite its clear promise, blockchain technology is not a panacea – existing solutions may still be best

Initially, IoT applications for blockchain technology will be focused on asset tracking and management. As a decentralized and trusted ledger, blockchain will be used to manage contract fulfillment for assets and packages as their status changes.

For example, food and pharmaceutical distribution often relies on a "cold chain" model that strives to keep shipments at the appropriate temperature throughout distribution. A blockchain can be used to prove each party's responsibility has been fulfilled at each step. The same blockchain can provide traceability, a health safety and security requirement.

Immutability

Immutability is a core advantage of blockchain, as it ensures the security of the data and prevents fraud and corruption.

But…

It also presents challenges when a record needs to be removed or rewritten.

Smart contract

Smart contracts are one of the benefits that blockchain offers. These are contract clauses, written in code and placed onto the blockchain. When a trigger event occurs, they will be activated automatically.

But…

These still need legal expertise. Clear regulatory frameworks need to be defined.

Speed issues

Blockchain will improve the efficiency of operations through streamlining processes and transparency.

But…

Blockchain has its own limits. The need to update every node means that updates are slowed as the network grows and alternatives can be much faster.

Private or public

Companies can choose to develop a public or private blockchain based on their business model.
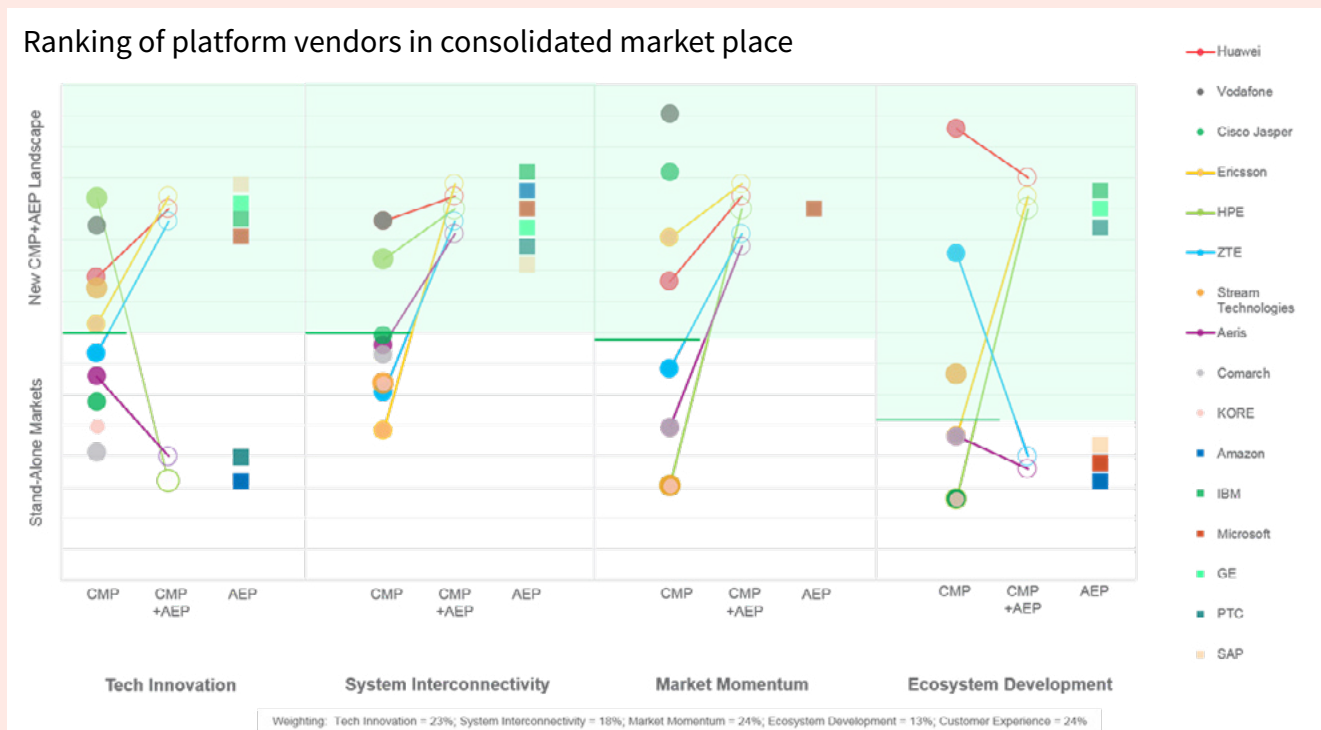
But…

Sometimes, one supplier can be involved in multiple supply chains. Interoperable blockchains are needed to enable transactions across public and private blockchains.

Wireless technology innovation

IoT platforms becoming more integrated

There are currently 400+ IoT platform providers. Many Connectivity Management Platforms (CMP) are moving up the value stack to incorporate Application Enablement Platform (AEP) and Data Exchange Platform (DEP) capabilities and provide highly integrated functionality for IoT application developers and adopters.
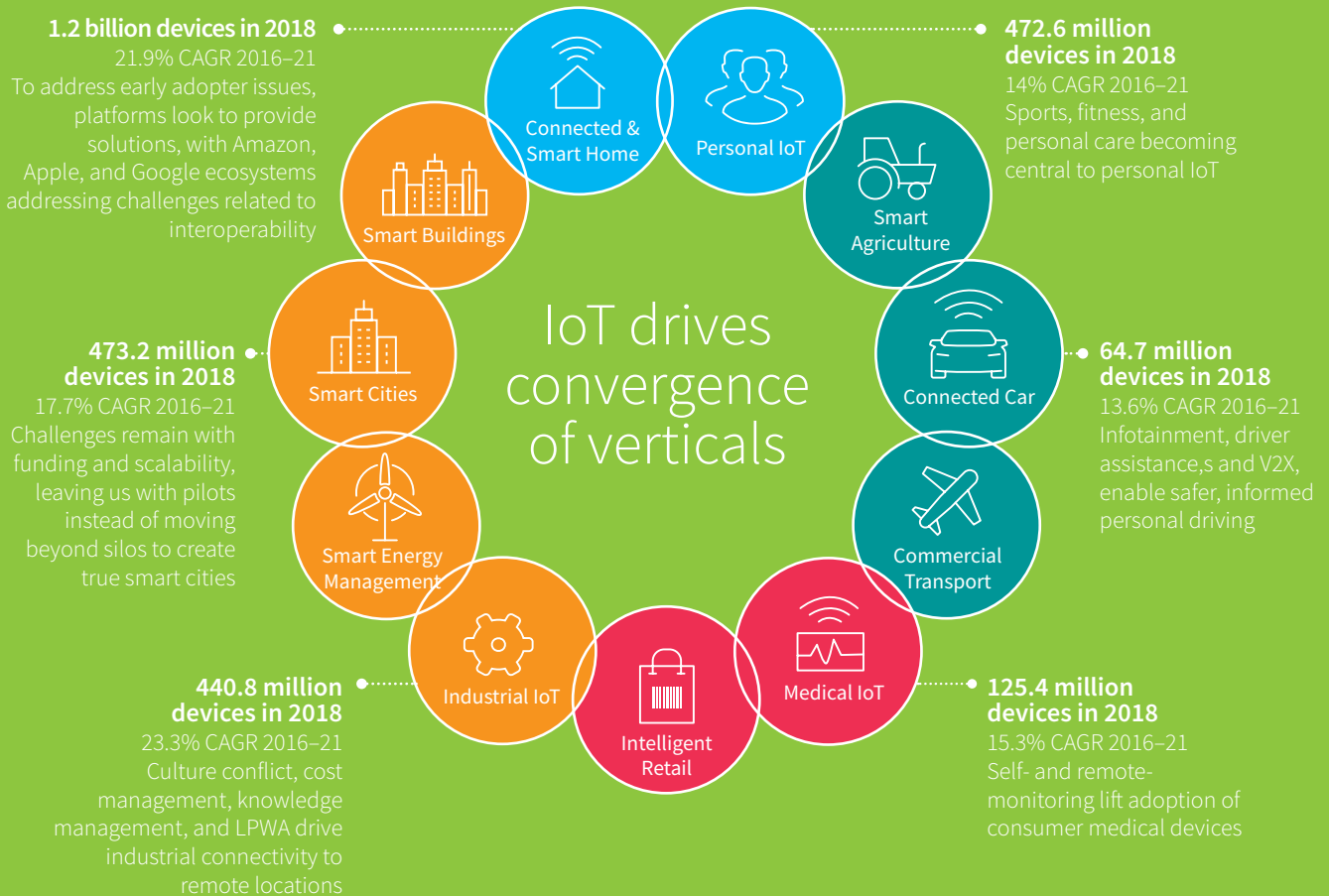
Assessing the CMP vendor landscape, it is clear that many vendors are using integration as one way to better compete across a number of measures.

Ranking of platform vendors in consolidated market place

Weighting: Tech Innovation = 23%; System Interconnectivity = 18%; Market Momentum = 24%; Ecosystem Development = 13%; Customer Experience = 24%

Create

Creation is the final and most significant step among the four phases of the IoT, as new and unique solutions are developed and emerging opportunities are identified.

What are the driving forces for growth in key IoT verticals?

1.2 billion devices in 2018
21.9% CAGR 2016–21
To address early adopter issues, platforms look to provide solutions, with Amazon, Apple, and Google ecosystems addressing challenges related to interoperability

472.6 million devices in 2018
14% CAGR 2016–21
Sports, fitness, and personal care becoming central to personal IoT

473.2 million devices in 2018
17.7% CAGR 2016–21
Challenges remain with funding and scalability, leaving us with pilots instead of moving beyond silos to create true smart cities

64.7 million devices in 2018
13.6% CAGR 2016–21
Infotainment, driver assistance,s and V2X, enable safer, informed personal driving

440.8 million devices in 2018
23.3% CAGR 2016–21
Culture conflict, cost management, knowledge management, and LPWA drive industrial connectivity to remote locations

125.4 million devices in 2018
15.3% CAGR 2016–21
Self- and remote-monitoring lift adoption of consumer medical devices

IoT drives convergence of verticals

- Connected & Smart Home
- Personal IoT
- Smart Agriculture
- Connected Car
- Commercial Transport
- Medical IoT
- Intelligent Retail
- Industrial IoT
- Smart Energy Management
- Smart Cities
- Smart Buildings

Innovation and competitiveness

IoT device shipments in Asia will reach 12.7 billion units in 2030

5G trial services will start in many Asian cities

– In South Korea, Korea Telecom (KT) will offer the world's first 5G trial service at the PyeongChang Winter Olympic Games in February 2018.

– In China, China Mobile plans to launch pre-commercial 5G service in June 2018 in six major cities and plans to deploy more than 10,000 5G base stations by 2020.

– On December 2017, KDDI (Japan's second-largest telecom service provider) and Samsung demonstrated 5G connectivity in a high-speed train traveling over 100km/hour.

NB-IoT to become the dominant IoT standard in Asia

– In May 2017, China's Ministry of Industry and Information Technology (MIIT) announced its decision to support the NB-IoT standard. Subsequently, MIIT provided the following NB-IoT standard target goals in China:

– Expand NB-IoT base station deployments from 400,000 in 2017 to 1.5 million 2020.

– Expand NB-IoT based M2M connections from 20 million in 2017 to 600 million in 2020.

– In July 2017, South Korea's KT Corporation and LG Uplus launched commercial low power wide area (LPWA) services based on NB-IoT technology.

Smart Home vertical will continue to post strong growth in Asia

– LG UPlus (South Korea's third-largest telecom service provider) is expected to surpass 1 million Home IoT subscribers before the end of 2017. LG UPlus will continue to demonstrate that a national telecom service provider can offer an attractive Smart Home platform solution for consumers.
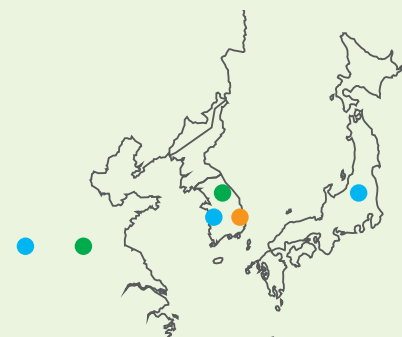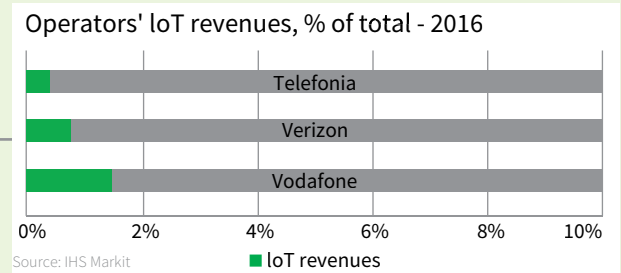
- 5G testing and trial service
- NB-IoT commercial launch
- Carrier smart home service

Business models

For operators, smart cities are a microcosm of the IoT

NB-IoT and LTE Cat-M1 represent an opportunity for telecom operators to expand their addressable markets for IoT connectivity. But how to move beyond connectivity and make meaningful money from the IoT remains a challenge for operators. In 2016, for instance, IoT revenue accounted for less than 2% of the group revenue of Telefónica, Verizon, and Vodafone.

Operators' IoT revenues, % of total - 2016

Telefonia	
Verizon	
Vodafone	

0%   2%   4%   6%   8%   10%

Source: IHS Markit   ▪ IoT revenues

6.7%
Q3 2016

Smart cities are, in many respects, similar to the IoT as a whole. Defining outcomes and ROI expectations, securing funding, and shaping appropriate business models can be challenging. But for operators, the challenge of smart cities also represent an opportunity to test a variety of business models, including charging for traffic or volumes, revenue sharing, outcome-based compensation, platform-as-a-service, and others. Connected lighting deployments, for instance, represents an opportunity for operators to leverage previously single-purpose infrastructure to enhance their network coverage.

Operators can play a central role in smart cities by leveraging strengths in connectivity, local presence, and understanding of local dynamics. As the market is still young, most operators are moving up the value chain through analytics and platform offerings. The opportunity to scale up can be achieved through M&A activity, as shown by Verizon's acquisitions of LQD WiFi and Sensity and Telia's purchase of Fält Communications. IHS Markit expects to see accelerated activity in 2018.

9.5%
Q3 2017

Standardization and security

Tech giants such as Amazon, Apple, and Google are extending their ecosystems into the smart home

Ecosystems born in mobile and IT space extending into smart homes and other IoT verticals

– Leverage mature, robust, and proven technologies such as IP, Wi-Fi, and Bluetooth

– Benefit from enormous economies of scale–billions of device shipments in mobile and IT

– Re-using technologies leverages large developer pools and existing software and apps

Voice is a key enabler of mainstream smart home adoption

– Ties ecosystems together and makes the ecosystem "sticky" for consumers

– More intuitive and accessible than control via mobile apps; voice feels natural

– Can be very inexpensive since little intelligence is needed at the edge

Ecosystem advantages for the consumer

– Enable DIY and retail smart home solutions by guaranteeing interoperability and security

– Backed by familiar and strong consumer brands

– Offer an incremental smart home adoption that is affordable and limited in scope, but remains scalable

– Delivers media, content, and services in addition to home automation

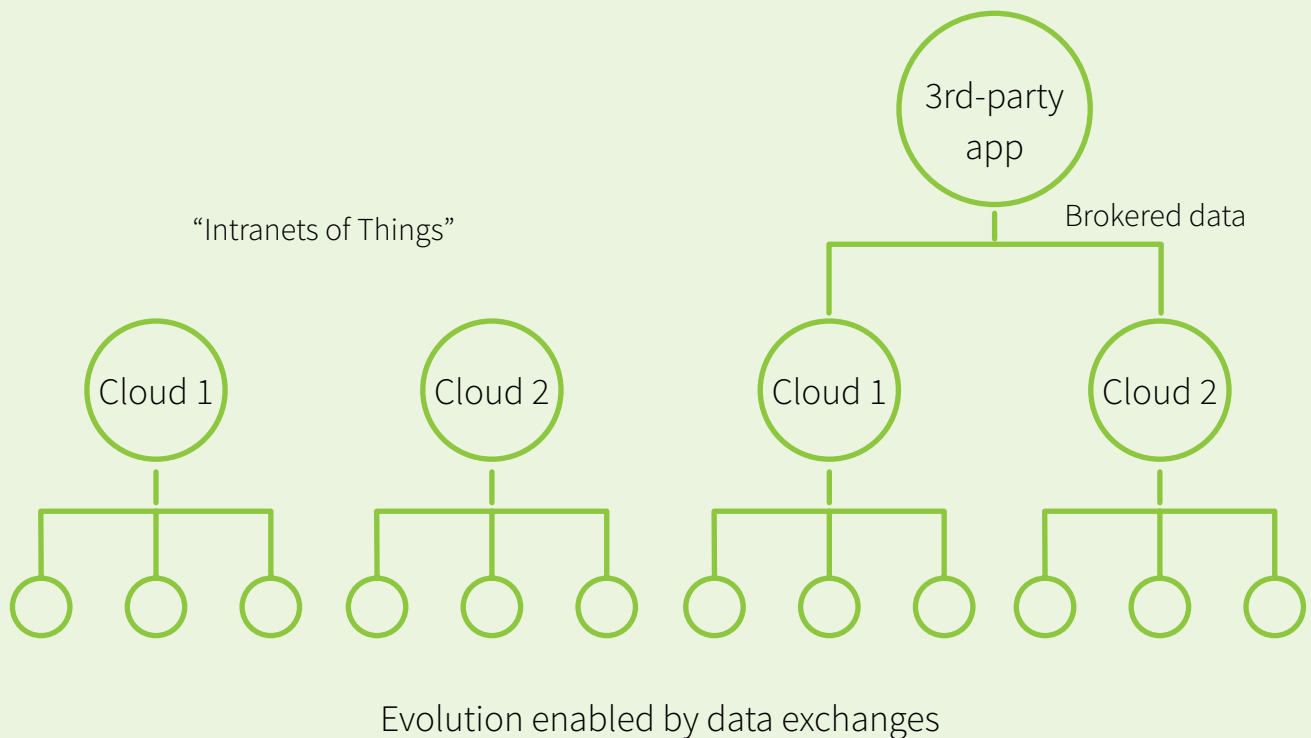– Can access user data such as calendars and contact lists to improve functionality of smart home applications

Wireless technology innovation

Significant innovation will occur when IoT app developers can leverage data from myriad deployed sensors, machines, and data stores.

A key inflection point for the IoT will be the gradual shift from our current "Intranets of Things" deployment model to a model where data can be exposed, discovered, entitled, and shared with third-party IoT application developers. This will spark tremendous new innovation as these third-party app developers mash up data without having to deploy their own sensors and devices in the field.

Internet of Things fueled by access to brokered data by third-party IoT app developers.

"Intranets of Things"

3rd-party app

Brokered data

Cloud 1   Cloud 2   Cloud 1   Cloud 2

Evolution enabled by data exchanges

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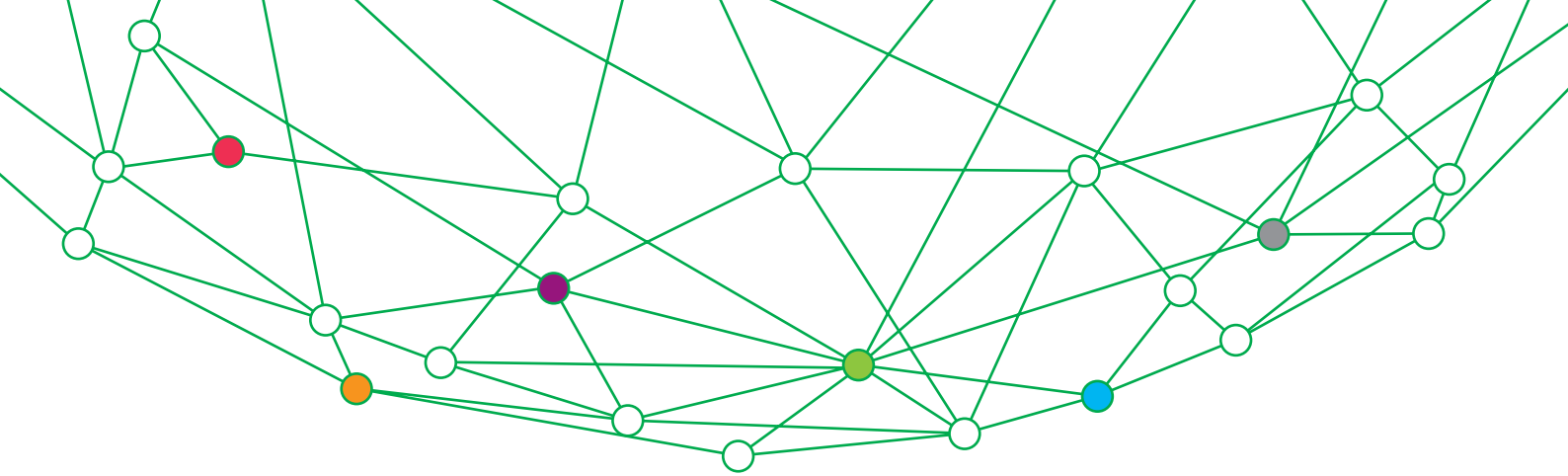Senior Principal Analyst
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Find out more

IHS Markit provides timely insight and analysis for more than 25 connectivity technologies in 34 application segments used for the Internet of Things.

For more information on wired and wireless connectivity technologies and the opportunities offered by the IoT, please visit
Critical Insights on the Internet of Things

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