IHS Markit™

Connectivity technologies

An in-depth view into the competition, applications and influencers driving the foundation of IoT

Start

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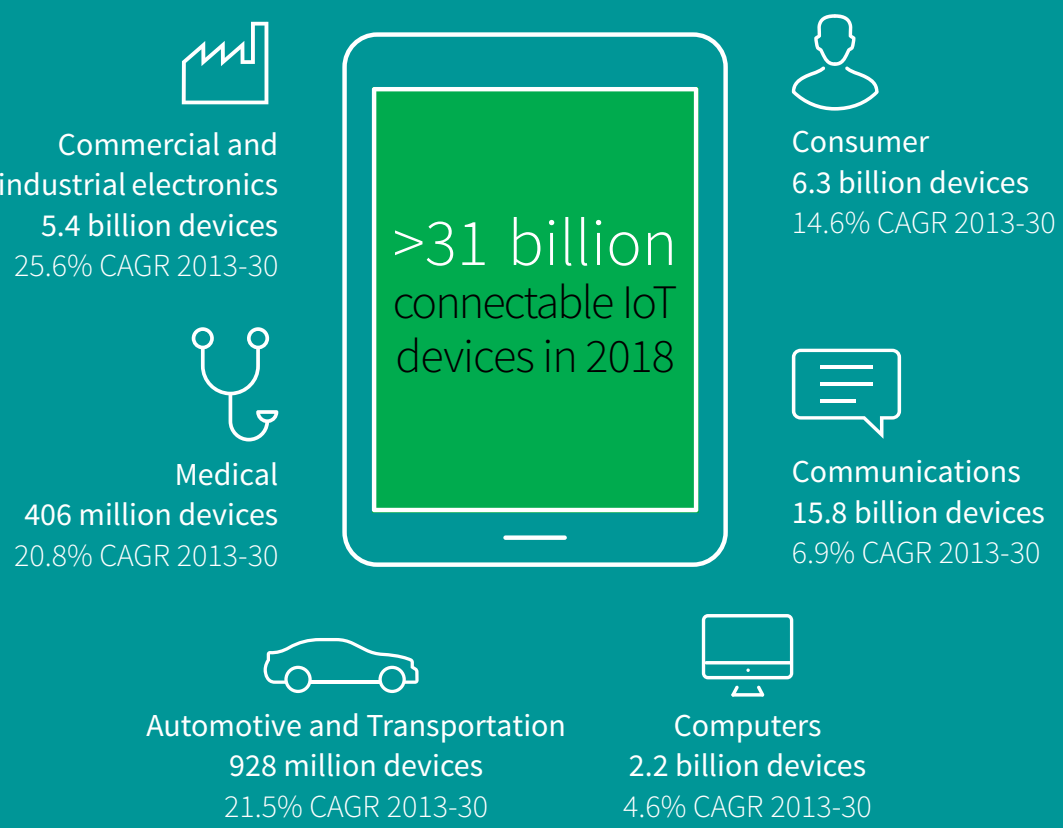
Connectivity's foundational role in the IoT

How many IoT devices will be connected globally in 2018?

- **Connectivity** is the foundational component of the IoT. This critical first stage is about embedding connectivity and processing capabilities into the devices all around us.
- **Adding sensors and storage** into these devices can yield a wealth of data to drive analytics, insights and ultimately business transformation.
- **Commercial and industrial electronics leads the way.** Driven by building automation, industrial automation and lighting, this market segment will account for over 50% of new installed connectable devices between 2018 and 2030.



From mission critical to massive IoT

The diversity of IoT use cases requires multiple technologies.

- IHS Markit tracks over 30 technologies enabling IoT connectivity.
- These technologies span wired and wireless, standards-based and proprietary, public and private, limited range and wide area, low and high bandwidth and unique and hybrid.
- This broad range of technologies reflects the diversity of IoT applications, from mission critical IoT, such as public safety, to the long tail of massive IoT use cases like asset tracking.

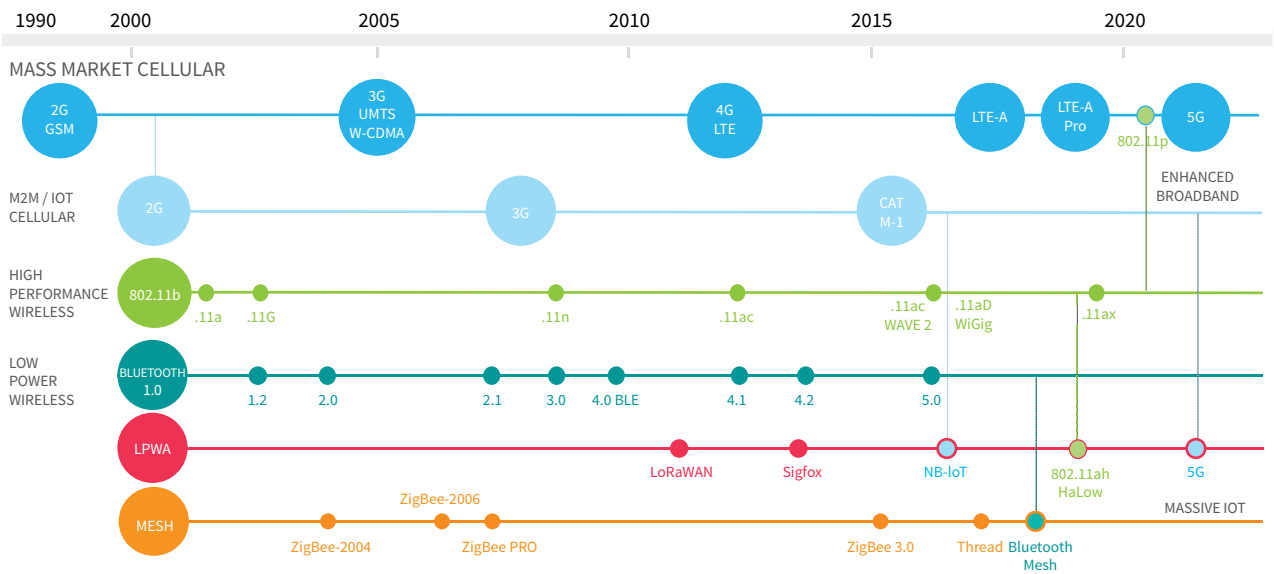
Key wireless technologies and their characteristics									
	5G	BLE	Cat-M1	LoRaWAN	LTE-A	NB-IoT	Sigfox	Wi-Fi	Zigbee
Open standards or proprietary	Open standards	Open standards	Open standards	Proprietary	Open standards	Open standards	Proprietary	Open standards	Open standards
Public or private	Public/ private	Private	Public	Public/ private	Public/ private	Public	Public	Public/ private	Private
Range	Wide	Short	Wide	Wide	Wide	Wide	Wide	Local	Short
Low or high bandwidth	High/low	Low	Low	Low	High	Low	Low	High	Low
Licensed or unlicensed spectrum	Licensed/ Unlicensed	Unlicensed	Licensed	Unlicensed	Licensed/ Unlicensed	Licensed	Unlicensed	Unlicensed	Unlicensed
Current Global Status	Not launched	Widely available	Limited availability	Limited availability	Widely available	Limited availability	Limited availability	Widely available	Widely available

The massive IoT opportunity is driving wireless innovation and spurring competition

This means increasing competition for massive IoT applications.

- Reliable connectivity and robust security are common requirements for mission critical and massive IoT use cases.
- While mission critical applications typically need high bandwidth, the core requirements for massive IoT include low cost of deployment, long battery life, mobility, geolocation and deep coverage.
- Such massive IoT requirements are driving the development of both established technologies such as Bluetooth, Wi-Fi and LTE and challengers like LoRaWAN, Sigfox and Thread.
- The end result: increased competition among wireless protocols for massive IoT applications and greater complexity for enterprises planning IoT projects.

Innovation continues across IoT wireless connectivity landscape

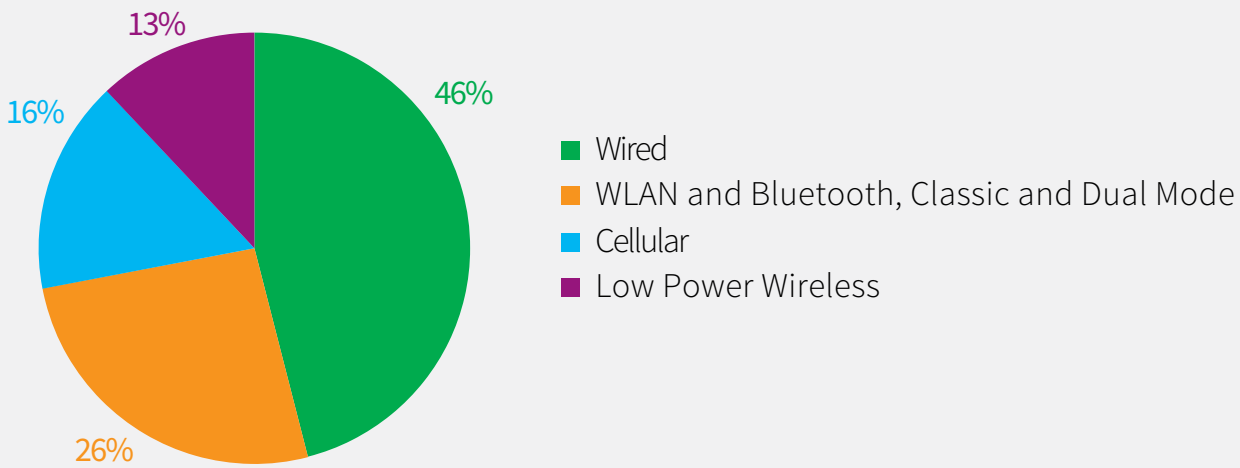


Wired technologies play a critical role in IoT connectivity

Long battery life, deep coverage and mobility requirements will drive low power and cellular technologies.

- Wired technologies accounted for 40% of connectivity IC shipments in 2017, reflecting the Ethernet's strong position in traditional large-scale application areas such industrial automation, lighting and power, and energy.
- WLAN and Bluetooth and Zigbee are entrenched in the Home Automation and Home CE segments.
- Massive IoT use cases are now driving demand for Cellular as well as Low Power Wireless.

Connectivity IC Shipments by Technology Group, 2018



Connectivity technologies – compete, complement or combine?

Compete

Compete: Through the NB-IoT and LTE-M enhancements, cellular will continue to evolve and compete directly with LPWA challengers LoRa and Sigfox in application areas like asset management/tracking and power and energy.

Complement

Complement: No single technology can address an enterprise's full IoT requirements. Consider tracking moving assets in the supply chain: a cargo container tracking solution may involve satellite connectivity at sea, cellular at dockside, RFID while passing through checkpoints and Wi-Fi when in a distribution center.

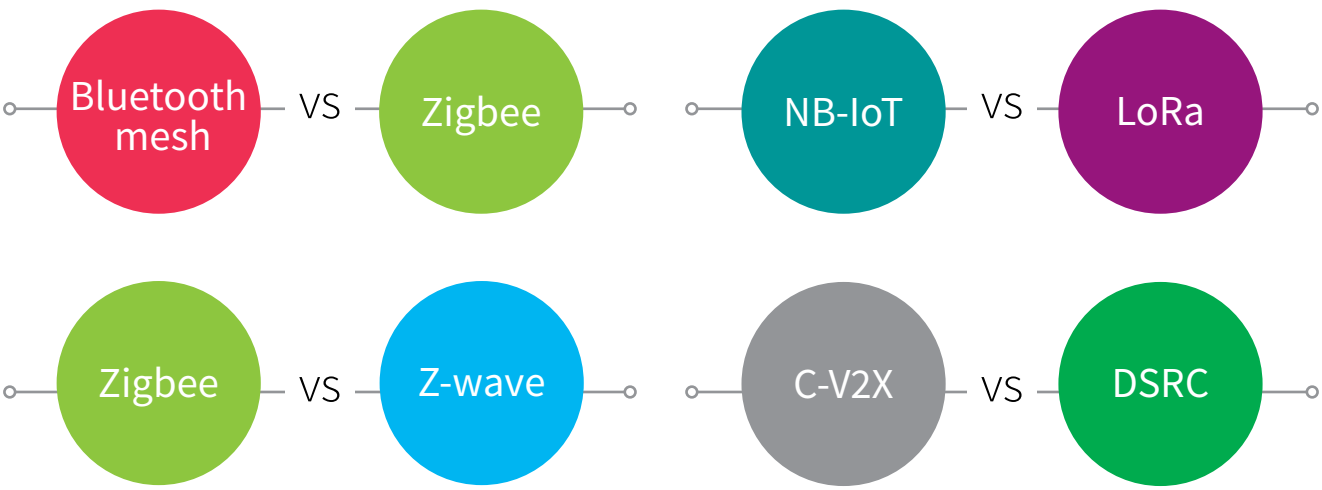
Combine

Combine: Bluetooth, DECT ULE, Wi-Fi, Zigbee and Z-wave and among the many wireless protocols used in smart home devices. The resulting fragmentation has meant complexity for end-users. To simplify the landscape, interoperable ecosystems are now being created around voice control, while module makers are integrating both NB-IoT and LTE-M connectivity to provide greater flexibility for enterprises.

Competing technologies – a look at the current landscape

Over the next few years, competition between technologies will intensify.

- Bluetooth Mesh is seeking to disrupt Zigbee's strong position in lighting.
- For its part, Zigbee will continue to address a broad range of consumer and industrial applications, while Z-wave will retain a strong position in security and home automation.
- Competition between NB-IoT and LoRa for the public network opportunity will grow as both technologies see wider global deployment.
- As carmakers prepare for an autonomous future, the ecosystem around C-V2X has quickly eclipsed that of DSRC.



Match: Bluetooth Mesh vs. Zigbee

Premiering in 2017

Challenger:

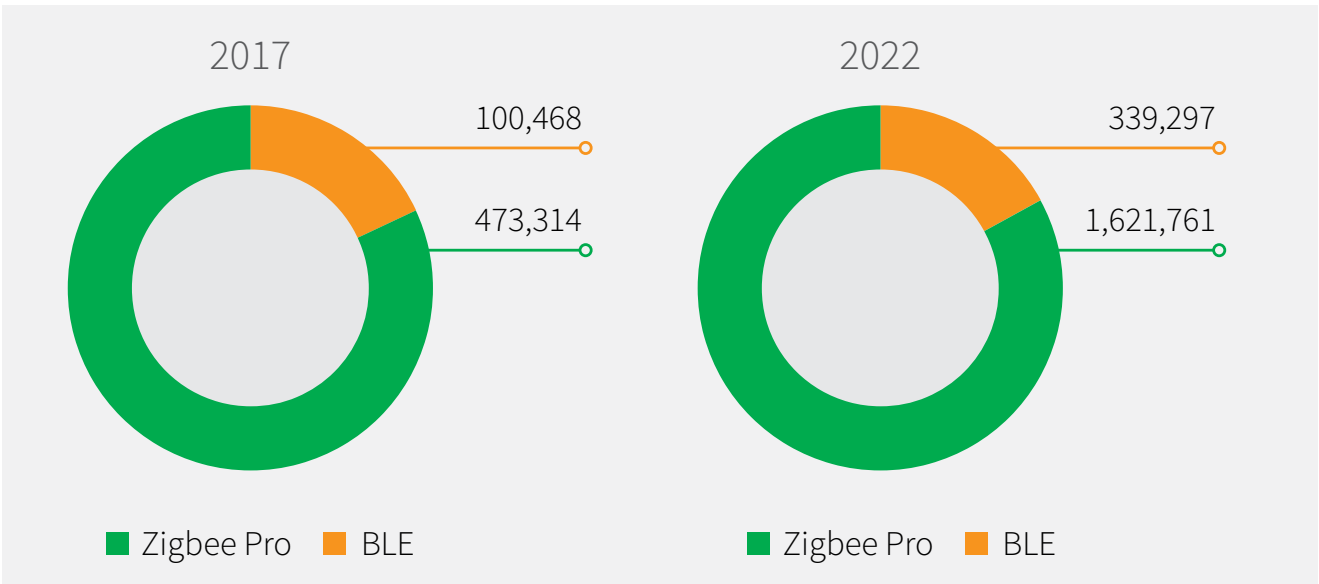
- After conquering the mobile and IT markets, Bluetooth has set its sights on the Smart Home and Industrial IoT, two of Zigbee's traditional target markets.

Battle:

- Bluetooth created the Low Energy specification in 2010 specifically to target the IoT, but it found that many applications, such as lighting and automation, require mesh technology, Zigbee's primary differentiator.
- Bluetooth added mesh networking in 2017, largely eliminating the most obvious Zigbee advantage.

Outlook:

- Zigbee has a very strong & defendable position in lighting and will be difficult to dislodge. However, Bluetooth has the advantage of being native to all mobile platforms and has an enormous ecosystem & installed base. Bluetooth will slowly erode Zigbee's position in most applications, even if Zigbee is better suited for the application.



Match: Zigbee vs. Z-Wave

Challenger:

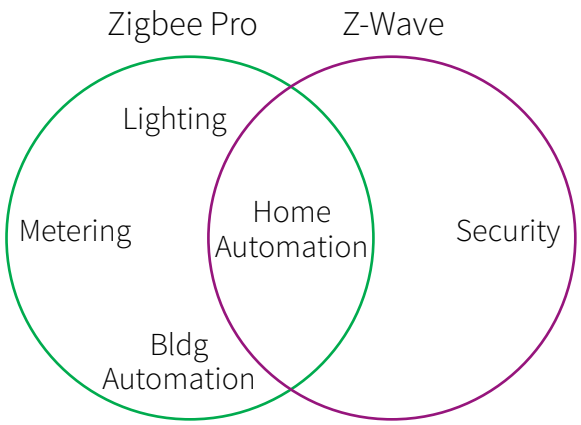
- Zigbee & Z-Wave have been going head-to-head for well over a decade in home automation and have proven to be evenly matched.

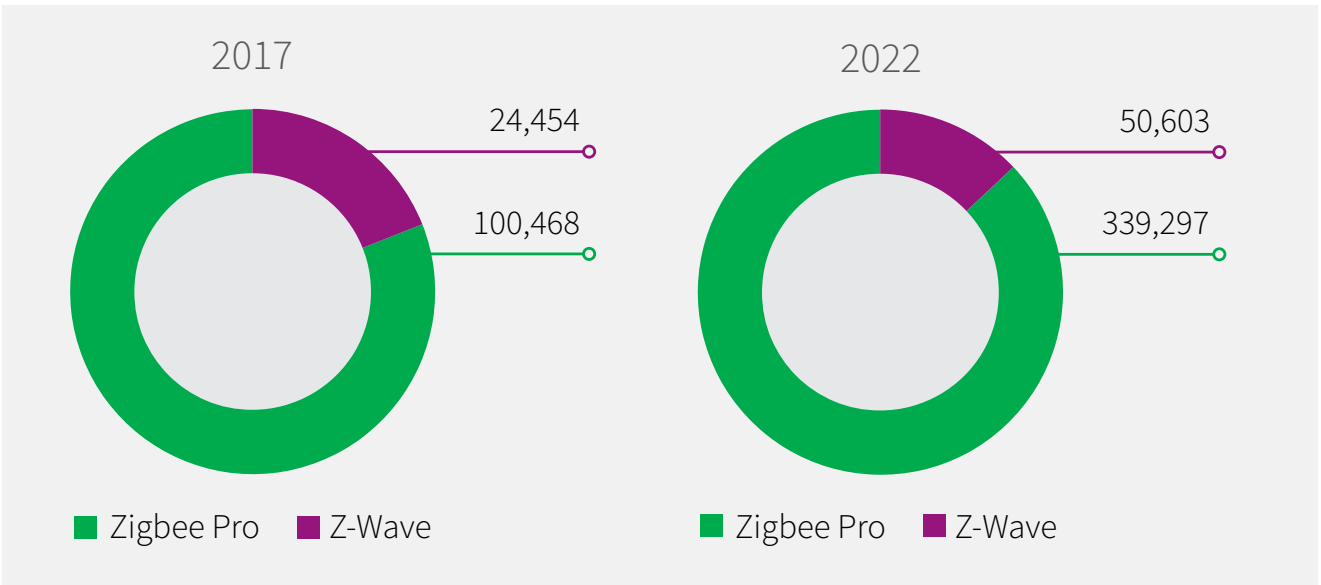
Battle:

- Zigbee has a robust ecosystem and is applicable across many consumer & industrial applications.
- Z-Wave is largely controlled by one IC vendor and has focused on home automation & security. Z-Wave is especially known for good interoperability and its appeal to pro installers.

Outlook:

- As a broadly applicable and open technology, Zigbee wins this fight, but Z-Wave will continue to dominate security and remain a leader in home automation. Ultimately, Zigbee's foes are Bluetooth and Wi-Fi, not Z-Wave





Match: NB-IoT versus LoRa

Premiering in 2018

Challenger:

- The fast development of the licensed NB-IoT standard has increased pressure on the unlicensed LPWA standards – particularly the market leader LoRa standard.

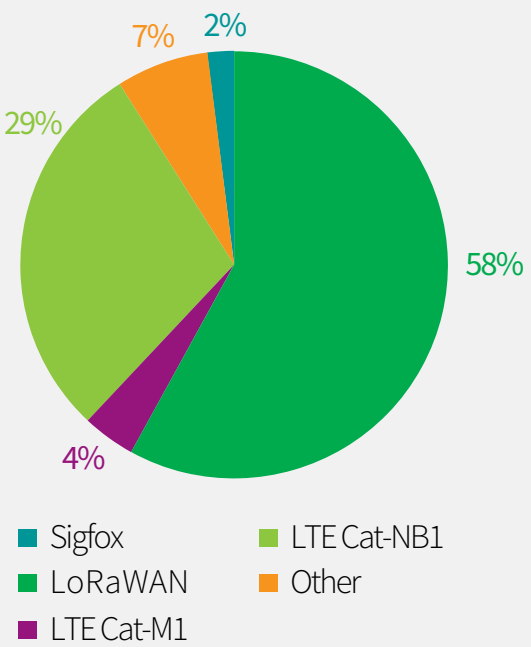
Battle:

- LoRa has been dominating the LPWA private network deployment.
- The next battle ground is within public networks, where LoRA and NB-IoT will compete to be the global leader.

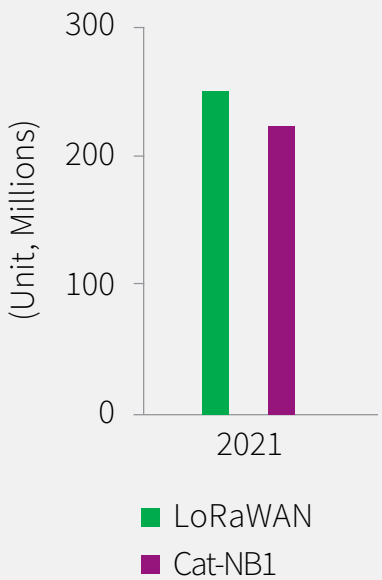
Outlook:

- LoRa is expected to remain the leader by a significant margin over the few several years mainly due to its early lead, diverse applications and widespread regional deployment. NB-IoT will be in fierce competition throughout the forecast period.
- LoRa and NB-IoT can co-exist in the market addressing different points along a spectrum of cost and bandwidth.

LPWAN IC shipments 2017



Module shipments forecast 2021



Match: C-V2X vs DSRC

Premiering in 2020

Challenger:

- Less than two years after the formation of the consortium 5GAA, the Cellular V2X ecosystem has outgrown those of the DSRC.

Battle:

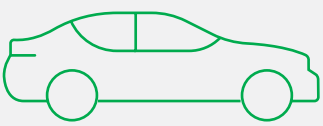
- The US Department of Transportation (USDOT) is currently reviewing the proposal to mandate DSRC-equipped vehicles, but unofficial sources indicate the proposal will not get approved, at least not in near future.
- The Chinese government has been actively backing the Cellular V2X technology.

Outlook:

- Cellular V2X is expected to expand its ecosystem and the first commercial launch of first C-V2X equipped vehicle is estimated to be released in 2020.
- Three major automobile manufacturers - Toyota, GM and Volkswagen – continue to support the DSRC standard. In the short-term, the V2X market will be fragmented between C-V2X and DSRC. In the long-term, C-V2X will gain momentum with introduction of advanced 5G V2X features.

DSRC-equipped vehicles on the road (May, 2018)

~120,000 units



Number of cities testing C-V2X by country

8	6	2	1

Connectivity outlook for industrial and consumer IoT applications

From industrial automation to sports, fitness and activity wearables, there exist a vast array of consumer and industrial IoT applications.

Connectivity from these types of applications can lead to improved processes, reduced expenses, new business models, better customer experience and greater safety.

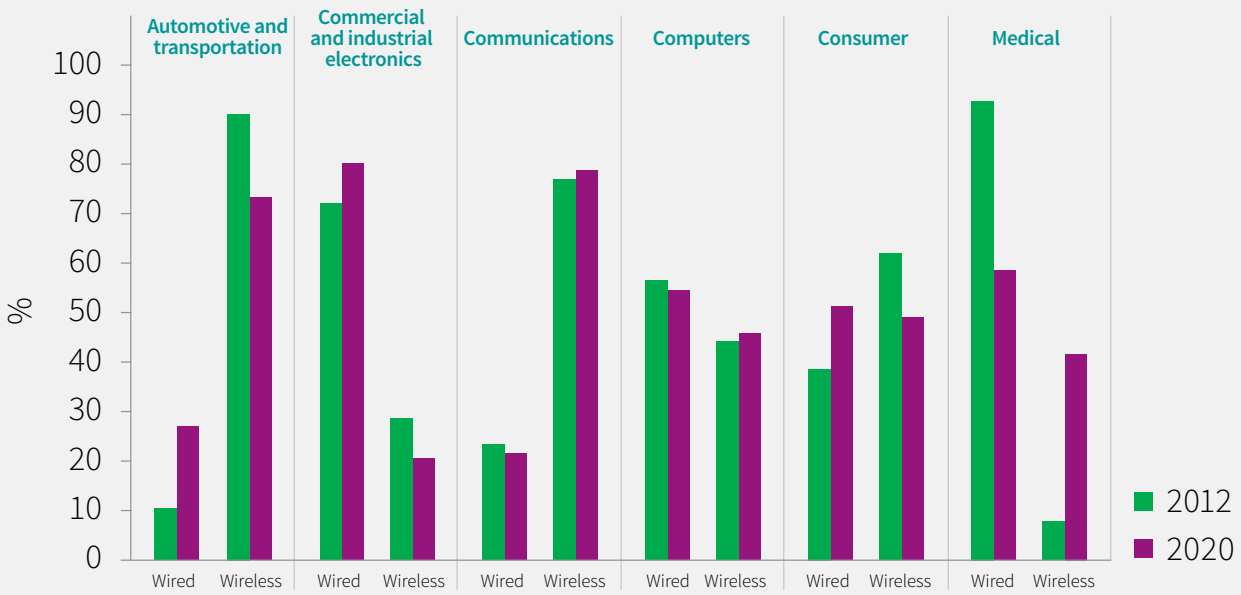
The advent of new LPWAN technologies supporting deeper reach, relatively low cost of deployment and long battery life will make it both technically and financially feasible to get visibility over assets that could not get connected before.

As they mature, both licensed and unlicensed LPWAN technologies address a greater range of applications from 2020 and beyond.

Wireless will account for at least 20% of connectivity IC shipments in each market segment

- By 2020, commercial and industrial electronics will surpass the consumer segment as the second largest market by IoT device shipments.
- Wired connectivity will remain critical in large-scale commercial and industrial electronics such as industrial automation, power and energy, and security and building automation.
- Wireless will play an increasingly important role in healthcare: healthcare providers need to track and trace costly equipment across large sites and monitor the condition of patients within their domestic setting.

Wired and wireless share of connectivity IC shipments by market segment



IoT Connectivity varies in Industrial World

Wireless will be increasingly important for industrial automation.

Application	Connectable Devices, 2018	Use Cases	Key Technologies – 2017	Key Technologies – 2020 and beyond
Industrial automation	1 billion	Condition monitoring; Location monitoring	Wired	BLE Cellular Cellular LPWAN (NB-IoT, LTE-M) Non-cellular LPWAN (LoRaWAN/ Sigfox) Wired
Power and energy	0.5 billion	Smart grid; Smart metering	Cellular Wired Zigbee	Cellular Cellular LPWAN (NB-IoT, LTE-M) Non-cellular LPWAN (LoRaWAN/ Sigfox) Wired Zigbee
Security and building automation	0.8 billion	Access and entrance control; Building automation; Fire detection; Video monitoring	Cellular EnOcean Wi-Fi Wired Zigbee Z-wave	Cellular Cellular LPWAN (NB-IoT, LTE-M) EnOcean Non-cellular LPWAN (LoRaWAN/ Sigfox) Wi-Fi Wired Zigbee Z-wave

IoT Connectivity varies by sector in the Consumer World

Wide area network (WAN) technologies seek to play a stronger role in the consumer space.

Application	Connectable Devices, 2018	Use Cases	Key Technologies – 2017	Key Technologies – 2020 and beyond
Home appliances	4 billion	Remote management; Order replenishment	Bluetooth Wi-Fi Wired	Bluetooth Wi-Fi Wired
Home automation	2 billion	Climate control; Energy and water management; Safety and security	Bluetooth Wi-Fi Wired Zigbee Z-wave	Bluetooth Cellular LPWAN (NB-IoT, LTE-M) Non-cellular LPWAN (LoRaWAN/ Sigfox) Wi-Fi Wired Zigbee Z-wave
Sports, fitness and activity	0.3 billion	Fitness and performance monitoring	Bluetooth Wi-Fi Wired	Bluetooth Wi-Fi Wired Cellular LPWAN (NB-IoT, LTE-M)

Connectivity landscape drivers

Edge computing, chipset vendor innovation and China will shape tomorrow's connectivity landscape.

IoT-enabled devices such as autonomous cars or security barriers will need to react in real time to events, captured by sensors, in their surrounding physical environment. For such mission critical applications, shifting computing power to the edge will be vital.

Semiconductor vendors, the foundation of the IoT, will increasing focus their investment on 14nm-7nm technology and software and ecosystem development, driving the connectivity agenda forward.

The NB-IoT push in China, driven by the government, Chinese operators and Huawei, will have global ripples.

Edge as an enabler

For IOT to expand, the Cloud and Datacenter need to operate closer to the sensor domain.

Edge at its most basic is a new deployment between the current end node and either the datacenter or cloud that provides the following attributes:

- Data aggregation and the ability to filter redundant sensor updates to the control domain in order to minimize unnecessary compute and minimize expensive networking bandwidth
- Real time or lower latency computing for time-critical workloads or safety applications
- Security functionality centralized or the ability to update software patches over time
- Resiliency for situations where the network connection is not optimal or when you need operations when the network is offline

Edge Gateways Influence Connectivity

Agriculture – provides real-time analytics on a LoRaWAN connected sensor network to change environmental outputs as conditions change

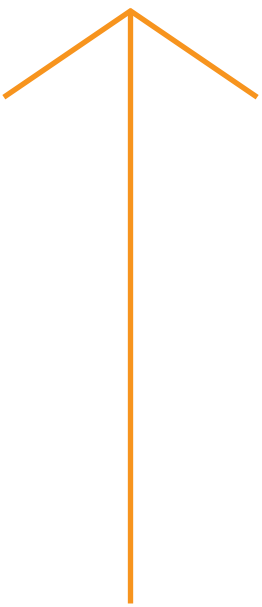
Factory – Wi-Fi connectivity will compete with new connected standards like ethernet TSN and 802.3cg

Security – situational awareness using video analytics to recognize unauthorized people or materials automatically will be bunded with wearables connected via RFID

Cost drivers for semi vendors

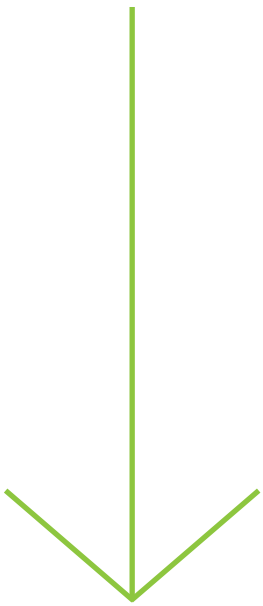
Increased pressure is forcing semiconductor suppliers to evolve their spend strategies to remain competitive, allowing larger vendors to promote their connectivity agendas.

14nm-7nm technology investments increasing dramatically



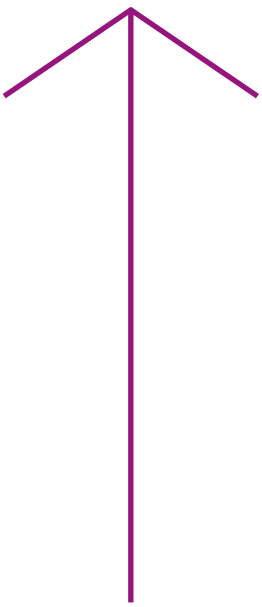
Number of ASSPs will decrease and become increasingly integrated

IP vendors commoditizing areas of differentiation (eg Arm, Risc5)



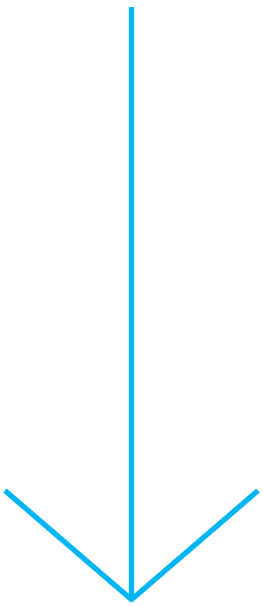
Mergers will continue externally and internally within product lines

Software and ecosystem investments will increase 2-3x in the next five years



SW and enablement becoming the customer selection criteria

Increased security and software spend provide limited ASP payback



Connectivity and sensor fusion with increased processing will compensate for ASP degradation

China influencing the global market

Rapid IoT growth in China has spurred strong interest in NB-IoT.

China Mobile, China Unicom, and China Telecom have collectively grown their cellular IoT connections from 54 million in 2014 to 335 million in 2017.

NB-IoT strongly backed by the Chinese government

- In June 2017, China's Ministry of Industry and Information Technology (MIIT) issued a new NB-IoT policy framework, resulting in greatly increased NB-IoT deployments by the mobile operators in China.

All three carriers testing 5G

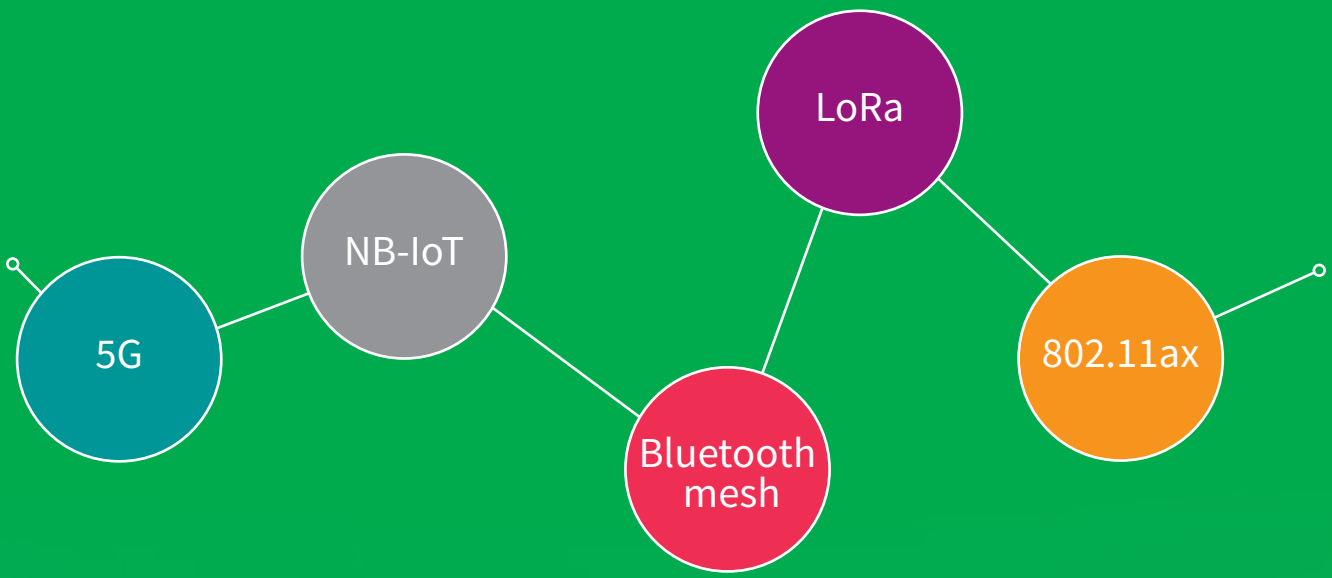
- China Mobile is conducing 5G field testing in five major cities - installing more than 100 base stations.
- China Unicom is about to conduct 5G pilot testing program in 16 major cities.
- China Telecom is about to commence 5G testing in six cities - the government is urging them add six more cities.

NB-IoT standard target goals set by the Chinese government

NB-IoT Goals	2017	2020
Base stations	400k	1.5M
Connections	20M	600M

Source: China's Ministry of Industry and Information Technology (MIIT)

5 connectivity technologies to watch



5G

The move to 5G will trigger significant investment across the value chain throughout the 2020s.

- Verizon and AT&T announced that they will deploy 5G service for the first time before the end of 2018. These 5G services will provide enhanced mobile broadband solutions – such as fixed-wireless access (Verizon) and mobile hotspots (AT&T).
- In March 2018, UK's Ofcom successfully completed its $1.9B USD 5G spectrum. Subsequently, other countries, including South Korea (June) and the United States (November), are setting dates for 5G spectrum auctions.
- 5G will start by addressing enhanced broadband uses cases, but in the end, industry, not humans, will be the chief 5G driver. Most growth in new subscriber connections will come from industrial use cases rather than consumer markets.

$2.4T	141M	63% in US
5G Value Chain CAPEX (2020-30)	5G IoT device shipments 2030	% of global 5G infrastructure spending 2020

NB-IoT

Strong NB-IoT deployment in China and in Europe will continue while LTE Cat-M1 remains dominant in the US.

- NB-IoT enables devices used in a wide array of applications, including but not limited to utilities (water, gas), digital sensor monitoring (temperature, humidity, corrosion), agriculture (irrigation system), location-based service (child monitoring) and smart cities (parking meters).
- In June 2017, China's Ministry of Industry and Information Technology (MIIT) issued a new NB-IoT policy framework, resulting in greatly increased NB-IoT deployments by all three major mobile operators in China.
- In Europe, major operators, including Vodafone and Deutsche Telekom, have been deploying NB-IoT networks.

$824M	364M	88% in Asia
Worldwide NB-IoT module revenue 2020	Worldwide NB-IoT shipments 2025	% of global NB-IoT connections 2020

Bluetooth mesh

Bluetooth's momentum and massive installed base gives it an advantage that will be hard for incumbent technologies to resist.

- Mesh technology is considered to be a requirement for wireless protocols in applications such as lighting and building automation. Bluetooth is late to market with mesh and must compete against the established Zigbee protocol as well as the newcomer, Thread.
- While still perceived as a consumer technology, Bluetooth is hoping mesh technology will allow it to cross over into commercial and industrial applications such as lighting and building automation.
- Bluetooth's dominance in IT and mobile markets gives it an edge over purpose-built incumbent protocols such as Zigbee. Bluetooth only has to be "good enough" in order to win adjacent markets over time – technical superiority is not necessary.

Bluetooth Mesh is compatible with all BLE devices back to the
v4.0 spec

1.1 billion
BLE devices shipped in 2020

392 million
Lighting and building automation devices shipped in 2022

LoRa

Enabling private networks and the use of unlicensed spectrum, LoRa ensures that it will remain differentiated in LPWA networking.

- LoRa has earned a leading role in the LPWAN market after shipping over 32 million nodes in 2017 and growing to over 57 million nodes in 2018.
- Despite intense competition from NB-IoT, LoRa is highly differentiated and more accessible, making it the LPWAN technology of choice for private networks and non-traditional service providers such as cable operators.
- LoRa's unmatched accessibility makes it the leading candidate to be "the Wi-Fi of LPWAN," a position that would make it the de facto choice for many LPWAN IoT deployments.

17.7 million
LoRa chips shipped into smart meters in 2017

71%
LoRa IC compounded annual growth rate from 2015 to 2022

350 million
LoRa node shipments in 2022

802.11ax

Introducing the next mainstream standard of the WLAN technology.

As greater numbers of Wi-Fi enabled devices are added into homes and enterprises, the 802.11ax standard will gain more prominence in the marketplace and is expected to become the de facto Wi-Fi standard in the next decade. The 802.11ax market will grow rapidly beginning in 2020, after the Wi-Fi alliance launches a certification program.

Recent developments around 802.11ax include:

- Korea's SK Telecom (SKT) tested the 802.11ax standard in November 2017. Korea Telecom (KT) followed by launching commercial Wi-Fi service based on the 802.11ax standard.
- Huawei launched its first 802.11ax enterprise access points in September 2017.
- During CES 2018, Asus launched its first 802.11ax customer access points.

$855M	67M	13%
802.11ax chipset revenue in 2022	Number of 802.11ax chipsets shipped in 2020	% of smartphones sold with 802.11ax connectivity in 2022

RootMetrics® By IHS Markit

Is your Network for Things ready for the Internet of Things?

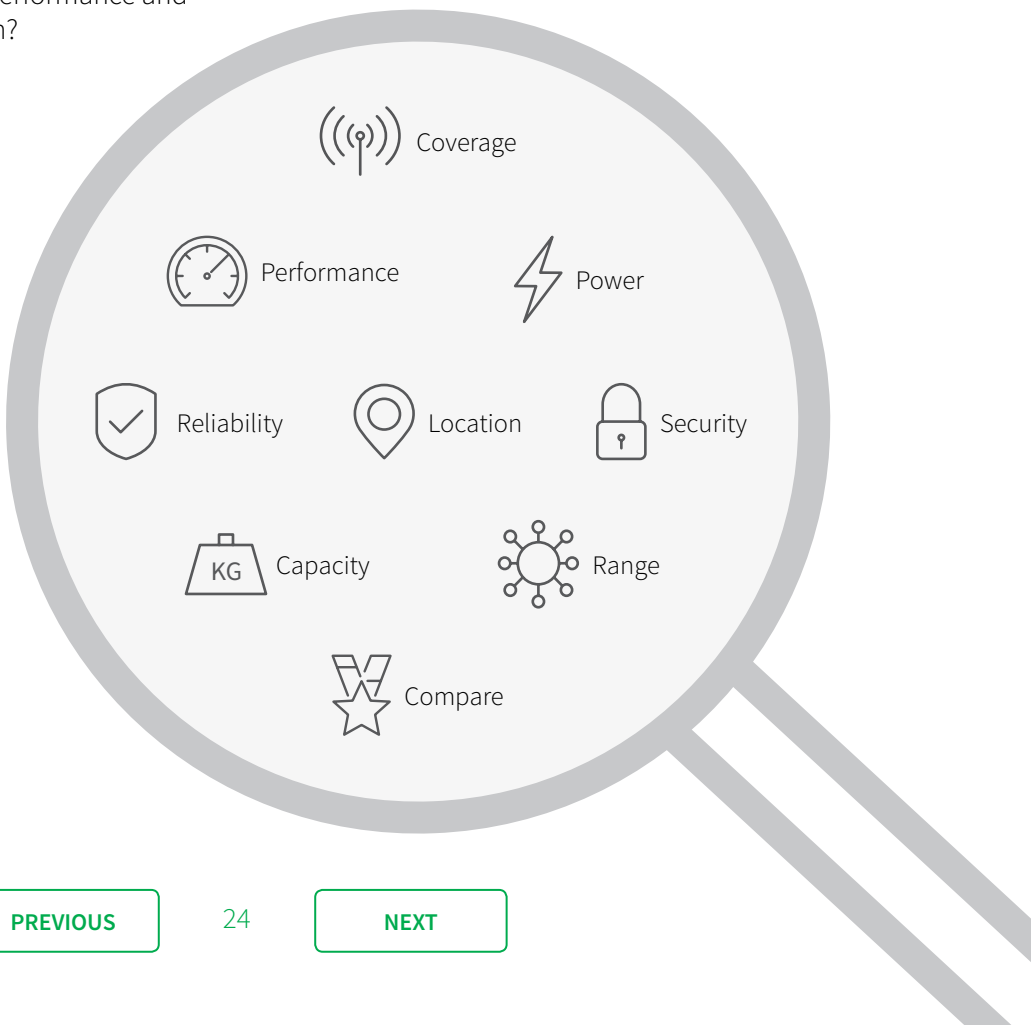
Real-world, end-to-end testing across the entirety of the complex IoT system provided by RootMetrics

The multiple challenges

- Is your network ready for demands of so many industrial IoT applications?
- Is the network providing enough security and reliability in the most critical application use cases?
- Is the IoT module you selected for your sensor going to perform in the real-world?
- Are you solving the technology challenges faced by most networks being deployed?
- Is the network providing enough coverage for your application?
- How is the competing network performance and coverage different than your own?

The one solution

- RootMetrics is the recognized standard for unbiased performance benchmark, cited by both the industry and press.
- A trusted source of independent, scientific insight into network & IoT performance under real-world conditions.
- A company with a dedicated analytics team to assure objective, accurate characterization of IoT networks.
- Gain advantage through competitive benchmarking of coverage, capacity and performance.



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 Comprehensive IoT research

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