5G and IoT
The time to act is now.
Introduction

The long-term performance capabilities of 5G have the potential to fundamentally transform many, if not all, industries. Nowhere will this be truer than for the “Internet of Things” (IoT) which will benefit significantly from 5G. As 5G develops, IoT solutions will be enabled by a network that is dramatically faster and more responsive, delivering significantly more bandwidth with more reliability and energy efficiency. It will have the capability of serving many times more connected devices – all at lower costs. These benefits can deliver tangible business results, enabling companies to increase operational efficiency, and drive innovation across products and business models.

At the same time, many of these benefits can already be unlocked today with 4G, and 5G will provide a transformational step as it becomes fully available. Most industries have recognized this potential and are expected to invest heavily in 5G and IoT, focusing on a variety of compelling use cases. It is paramount to embark on your IoT journey today – starting with 4G – to become a first mover, setting yourself up to take advantage of 5G once it is broadly deployed.

IoT – A key driver of 5G

5G is the latest technical standard for mobile cellular networks. In contrast to previous standards, 5G has been designed in both an evolutionary and revolutionary approach, in the spirit of “Long Term Evolution” (LTE). Prior to 5G, networks were designed primarily around consumers and their personal mobile devices.

The emergence of IoT has led to the need for dramatically different characteristics and technical capabilities in cellular networks. At the core of optimization are latency, reliability, connection density, low-cost and low-power capabilities, capacity, and speed. 5G aims to support use cases that feature thousands of connected “things” per cell and/or require real-time responsiveness. 5G delivers on evolving enterprise and industrial networking requirements while also improving the consumer experience.

The 3 categories of 5G use cases

5G has been designed for 3 broad categories of use cases – Enhanced Broadband, Massive IoT Sensing, and Critical IoT – that were intended to serve a multitude of enterprise and industrial applications.

5G not only introduces new technologies, but also builds upon existing infrastructure by enhancing the capabilities of 4G technologies to a completely new level. While 4G offers significant speed improvements over previous generations, it typically cannot match the performance of fixed-line connections. With 5G, wireless performance will be on par with fixed-line connections in many instances, enabling an “Enhanced Broadband” experience.

NB-IoT and Cat-M ¹ are 4G standards designed for use cases that involve vast amounts of connected “things,” such as devices, machines, and sensors. These standards allow more devices to connect at higher levels of energy efficiency – a significant development as many IoT use cases are only economical if each connection is cost effective. 5G takes this further with “Massive IoT Sensing,” allowing 10x more devices to connect at 100x the energy efficiency compared to LTE-Advanced.

¹ Cat-M and Narrow Band IoT (NB-IoT) both lowered device and connectivity costs through different means: Cat-M by reducing energy-intensive features, while NB-IoT is a network specifically designed for IoT devices.
The third category of use cases, "Critical IoT," includes those that are particularly time sensitive and have high reliability requirements. For example, connected machines that operate autonomously require extremely low latency to react to external factors in real time and prevent costly errors or accidents. Even many stationary use cases require maximum reliability. Consider the case of connected machinery in a factory where even minor lapses in communication can result in a production line halt – leading to lost productivity and, in extreme cases, equipment damage and human injury. Unlike previous standards, 5G is optimally designed for these requirements.

To enable these new use case groups, 5G was designed to enhance six key capabilities. The following figure highlights how important IoT was in defining what 5G would be.

**Figure 1 – The importance of IoT in defining 5G**

- **Low Latency**: Autonomous cars or robots need to react to unanticipated real-world events – like a child crossing a road or unexpected pathway obstructions – in real time. This requires ultra-low latency connections to communicate data. Other technologies such as Augmented Reality (AR)/Virtual Reality (VR) can suffer from distorted imagery and lose sync at high latencies.

- **Ultra-Reliable**: Fully connected supply chains and automated production facilities depend on continuous connections. Even short dropouts or fades can lead to errors in mission-critical processes with significant economic consequences.

- **Higher Density**: Artificial intelligence and advanced analytics require seamless streams of data from multiple, distributed sources. High network density is needed to manage scale and volume, handling data as close to the source as possible.

- **Low Cost, Low Power**: Enhanced logistics unlocks value by tracking even the smallest inventory item, and other industries increasingly use connected sensors to monitor their various assets in real time. Doing this economically requires devices that operate at low power levels and networks that offer low-cost connectivity options.

- **Enhanced Broadband**: A major constraint of current mobile broadband networks is the drop-in speed and performance users experience once too many devices are connected. 5G can handle far more devices, alleviating a cell’s capacity strain.

- **Higher Speeds**: Bandwidth-intensive activities, such as content streaming and high-resolution AR/VR, will increase demand for higher speeds. While 4G can handle most use cases at degraded quality, 5G networks will be able to sustain high performance levels to assure a top-quality end-user experience over multiple devices.

**5G and IoT benefits are multi-faceted and tangible. How can your business realize them?**
**IoT and 5G – Making the business case**

Nearly every business can profit from the combination of 4G/5G and IoT. Most benefits are derived from increases in productivity, improvements in customer experience, creation of new business models, or a combination of these aspects.

**Figure 2 – IoT and 5G benefits**

![Diagram showing the benefits of IoT and 5G](image)

- **Optimized efficiency**: Manual processes are often time consuming and costly. If performed in the field, inefficiencies in scheduling, dispatching, and travel can further increase costs. IoT enables companies to automate processes and perform tasks remotely, introducing efficiencies that significantly impact the bottom line.

- **Optimized reliability**: Downtime caused by human error or unforeseen external factors can severely hurt business, with the impact only increasing as the world becomes more connected. 5G aims to maximize network reliability.

- **Optimized visibility and data collection**: Today, understanding the status and position of assets can often be time consuming, if not impossible. With the help of 5G-enabled sensors, assets can be monitored remotely and performance data can be shared in real time, reducing costs and improving customer satisfaction.

- **Optimized customer experience**: IoT can improve customer care by reducing time to action and frequency of interactions, which are often time consuming and frustrating in the eyes of the customer. IoT devices give businesses a deeper understanding of customer experience, enabling improved care and response.

- **New products & services**: IoT opens up opportunities to add features to existing products. By intelligently connecting and adding sensors to equipment, businesses can provide and monetize new services such as asset tracking and predictive maintenance.

- **New ways of working**: IoT also presents an opportunity to change how people work. With the help of AR or VR, workers can receive highly personalized training, obtain support from remote specialists, or work remotely themselves. This reduces idle time and empowers the workforce, improving productivity and employees’ quality of work.

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**Most industries are already on the move towards IoT and 5G.**
Industries primed for 5G/IoT

No industry will be unaffected by the rise of IoT. The biggest potential lies in shared real-time data between various devices, machines, or any other “thing” that can be connected, including innovative interfaces between machines and humans. This can be true for both smaller specialists and global conglomerates. In general, the more assets a company operates or manages, the larger the IoT opportunity.

Figure 3 – Expected investments in IoT & 5G services by industry (excl. equipment & devices), (US, cumulative 2020-2030, in USD bn)

The following are examples of how some of these industries are expected to invest in IoT and, subsequently, in 5G capabilities:

**Healthcare:** The healthcare industry will see profound changes with 5G. The entire care ecosystem will be connected, bringing patients closer to their physicians than ever before: in an emergency, ambulances will be able to seamlessly communicate with hospital staff, chronic and newly released patients will be closely monitored through innovative, connected technology, and the elderly will be assisted by robots. Similarly, patient diagnoses, examinations, and follow-ups may be performed remotely. Networks with high bandwidth, low latency, and high reliability will be required to enable the technologies needed to achieve this new future of healthcare.

**Manufacturing:** The rise of automation in manufacturing has been a longstanding trend. IoT now allows for machines to directly communicate and self-coordinate production with minimal involvement of human labor. In addition, with inventory tracking, automated workflows involving suppliers and customers can be designed to develop entirely connected ecosystems. For such complex systems to work effectively, manufacturers need ultra-reliable real-time connectivity. Data must be collected and handled from a variety of distributed internal and external sources, whether they be mobile or stationary.
Energy: The energy sector has become increasingly complex, driven by decentralized generation and a higher share of renewable energy that cannot be forecasted as accurately as conventional sources. To maintain efficiency in this changing world, energy companies need to become much more agile, which is only possible by connecting assets along the value chain – spanning generation, transmission (e.g., through grids or pipelines), and distribution. Energy players often enlist large field service teams that can benefit from improved remote monitoring capabilities and innovative digital support. Networks connecting these field functions to intelligent central steering facilities will need to be particularly dense and reliable, capable of supporting low-latency applications.

Public: The public sector operates a range of diverse infrastructure-based assets that will become increasingly digitized. Next-generation use cases include real-time management of citywide video surveillance, remote monitoring and management of traffic and road conditions, and “smart” emergency response initiatives through IoT technology, among a myriad of others. Public transportation will be a major beneficiary of IoT solutions, which will enable an array of functions ranging from automated rail traffic management to construction and maintenance monitoring. These use cases require particularly dense networks, high energy efficiency, and low latency.

Automotive: The automotive industry is experiencing a revolutionary transformation not seen since its earliest days. Autonomous driving, electric drivetrains, and the growing popularity of vehicle-sharing platforms may soon lead to the emergence of autonomous vehicle fleets, potentially replacing today’s large number of private and public transport vehicles. To optimize these fleets, each vehicle will need to be connected to each other (vehicle-to-vehicle) and also to central entities (vehicle-to-infrastructure) that coordinate traffic flows in real time. Connected vehicles are prevalent even today: corporate fleets are remotely managed via IoT technologies while consumer vehicles are equipped with connected monitoring/maintenance features and smart infotainment systems. The automotive industry will depend on low-latency networks that are dense and reliable in order to serve these diverse requirements.

Retail: The retail industry is best positioned to benefit from improvements in customer experience led by IoT and AI advancements. With the help of 5G, customers will enjoy a more tailored and streamlined experience, both at home and in the store. Retailers will be able to optimize their store layout and product positioning with the help of video analytics, while customers will enjoy a personalized experience shopping or contacting customer care through AR/VR. To make this vision a reality, retailers will need access to a high-density, high-capacity network.

Which use cases are most relevant for your business?
Major IoT and 5G use cases across multiple industries

Figure 4 – Major IoT and 5G use cases

- Retail
  - Customer experience
  - Pop-up kiosk
- Manufacturing
  - Autonomous mobile robots
- Public
  - Traffic management
  - Video surveillance and analysis
- Automotive
  - Electric vehicle charging
  - Driver safety
  - Fleet management
- Healthcare
  - Connected ambulance
  - Remote patient monitoring
  - Assisted living robots
- Energy
  - Smart meters
  - Smart grids
  - Productivity
  - Revenue / Cust Experience

Do I have to wait until 5G capabilities are fully deployed?
Start your 5G IoT journey with 4G

Many IoT use cases are already technically and economically viable today and do not depend entirely on the wide-scale introduction of 5G.

The following section looks at the capabilities supported by today’s enhanced 4G networks and the emerging 5G technologies that will unleash the full potential of 5G IoT in upcoming years.²

Low Latency

4G: 4G networks were originally designed to support end-to-end latencies of 50-100 ms, which is considerably faster than 3G. In recent years, lower latency has become more important for many IoT use cases.

Networks are being redesigned ahead of the introduction of 5G, implementing edge computing architecture that moves key network elements and customer data closer to the network edge. Such designs can reduce end-to-end latency even further. These enhancements in core latency enable a number of IoT use cases.

5G: In addition to the benefits stemming from edge computing adoption, 5G New Radio enhancements such as mini slots and grant-free uplink will bring latency improvements to the radio access network. These will enable end-to-end latencies below 10 ms. Highly latency-sensitive use cases will also leverage network slicing to accommodate specific workloads. This will allow for the movement of non-critical traffic to other slices, ensuring that critical workloads are uncontested.

Ultra-Reliability

4G: 4G LTE was designed to support 99.999% reliability by allowing for the retransmission of data. The cost for achieving this high level of reliability was the limitation of low latency potential in the radio access network.

5G: 5G is designed to achieve both enhanced reliability up to 99.9999% and ultra-low latency. The primary drivers for improved reliability will be the virtualization and distribution of the core network as well as redundancies in 5G New Radio topologies.

Higher Density

4G: 4G LTE today supports a vast array of smartphones, tablets, hotspots, and IoT devices, and performs suitably for many existing use cases.

5G: A 5G/IoT world where practically everything is connected will require a network that can support a 10x increase in density compared to current levels. This can be achieved through additional spectrum, Massive MIMO, and built-in 5G New Radio capabilities.

² Performance characteristics are based on general LTE and 5G technical specifications and does not reflect the network performance of any specific wireless carrier.
Low Power / Low Cost:

4G: 4G LTE was originally designed to support the speed and capacity needs of smartphones. In later releases, new 4G specifications such as **NB-IoT** and **Cat-M** were introduced to address the needs of low power and lower cost IoT sensors and devices. At the cost of higher speeds, **NB-IoT** and **Cat-M** allow for up to 10 years of battery life in IoT devices and greater coverage in hard-to-reach locations. These standards are particularly economical to deploy.

5G: 5G will help further improve IoT equipment battery life. For example, **5G New Radio** will reduce how often radios need to check in with the network, lowering battery consumption and broadcasting overhead.

Higher Speeds & Capacity

4G: 4G LTE was introduced in 2010. Since then, it has gone through several enhancements that have ultimately made it faster. LTE Advanced can deliver data speeds up to 1 Gbps under lab conditions and averages 25-50 Mbps under normal real-world conditions. Key enhancements include:

- **Multiple Input Multiple Output (MIMO)** – enabling multiple streams of data to a device
- **Carrier Aggregation** – aggregating multiple channels of spectrum to create a much larger data pipe

5G: 5G promises to be much faster. 5G can deliver speeds up to 20 Gbps in the lab and is expected to average 100-300 Mbps under normal real-world conditions. This increase in speed has been achieved through the following technologies:

- In addition to existing low- and mid-band spectrum used by 4G networks, 5G will be deployed on **high-band mmWave spectrum** (24GHz through 100GHz), exponentially increasing the amount of spectrum available for use
- Whereas operators were limited to 20Mhz channel bandwidth in 4G networks, they will now be able to utilize channels of 400Mhz in size, delivering much greater capacity and speeds
- MIMO was limited to 8 transmit and 8 receive streams in 4G networks. Newly-deployed **Massive MIMO** can feature up to 64 transmit and 64 receive streams, potentially resulting in 10x capacity increases
- Active antenna systems with **3D Beamforming** will allow for the precise targeting of users and devices

Are there real-world examples today?
Where can you see the 5G evolution in the real world?

**Video Surveillance & Analytics**

With the help of IoT, video surveillance can be taken to the next level and used to enhance both operations and safety. Modern solutions offer not only enhanced video quality and storage, but also analytics that provide insights such as potential threat detection or optimized traffic flows. Video surveillance can now be a revenue creator; for example, by informing a retailer's floor plan changes to drive sales. With 5G and AI, surveillance cameras will be able to stream high-resolution video to the cloud, while edge computing will be able to analyze certain elements and detect hazards in real time.

**Driver Safety**

By combining sensors, cameras, AI, and LTE connectivity, modern fleet management solutions help prevent accidents by coaching drivers in real time. The solution identifies distracted driving, while also monitoring the external environment and ensuring that drivers are keeping a safe distance from other vehicles on the road. These solutions can also reward safe drivers and identify and coach high-risk motorists. Fleet management solutions also provide the information needed to speed up claims processing. In a 5G world, cars will be able to communicate with each other to avoid accidents.

**Remote Robotics**

Advances in robotics technology are making mobile industrial robots a reality. Mobile remote-controlled robots are making their way into warehouses, factories, and disaster zones, often enabled by a 4G network. On a lower-latency 5G network, the controller will be able to receive feedback from the robot in real time and react instantly, providing live on-site capabilities.

**Connected Hospital**

The connected hospital can deliver a better patient journey by providing an advanced medical environment and improving patient outcomes. With existing technologies, hospitals can monitor temperature and air quality, remotely monitor patients, and track medical equipment. With 5G, hospitals will become even more connected. AR technology will be used to train and increase the skills of medical staff, and patient monitoring applications will be able to aggregate data to analyze at the edge, enabling medical staff to intervene faster with accurate patient data.

The time to act is now.
Now is the time to start your future with IoT and 5G

The 6 steps to success

Many IoT and 5G-enhanced / 5G-enabled technologies have either already been implemented in real-life settings or are currently undergoing pilots. Assessing the business benefits, evaluating underlying technology choices and alternatives, building requisite partnerships and capabilities, preparing implementation plans, running pilots, and scaling up operations, among other tasks, are time consuming – businesses need to start preparing now.

1) The journey begins with understanding where you stand today and where you want to go with 5G and IoT. A clear vision for your future operations is critical to informing your next steps.

2) How can 5G/IoT capabilities help you achieve your vision? From enabling your workforce with enhanced mobile broadband connectivity, to equipping your products with IoT functionality, to increasing productivity in your own operations with enhanced visibility, control, and automation – the possibilities are endless.

3) To build these capabilities, what (IoT) technologies are needed? Desired outcomes must be well understood and mapped to the appropriate hardware and software.

4) Now, connectivity needs to be addressed. Requirements should be carefully documented to help select the ideal connectivity technology. Keep 5G on your radar, and consider the capable technologies of today: LTE, NB-IoT, Cat-M.

5) Before implementation begins, taking the time to calculate a business case will reduce risk and bring clarity to the value to be delivered.

6) Finally, a well prepared implementation plan backed by strong execution capabilities is the key to a successful rollout and realizing the business benefits.

Take the first step

Embarking on a technology journey can be challenging – particularly one that involves a transformation that will impact your entire organization. The potential that 5G and IoT deliver makes that first step worth the effort. Sprint Business has experts who can share a deeper understanding of 5G and IoT and who can help you develop the strategic insights you need to prepare your organization for this transition.

Book your one-on-one session with a 5G/IoT specialist today. See more details on sprint.com/discovery.
Editorial notes

This paper was jointly developed by Sprint Business and Arthur D. Little.

Arthur D. Little has been at the forefront of innovation since 1886. We are an acknowledged thought leader in linking strategy, innovation and transformation in technology-intensive and converging industries. For further information please visit www.adlittle.com.

Arthur D. Little has been actively involved in the consultations, development and launch of many generations of telecoms technologies including 5G and IoT, navigating clients through changing business ecosystems to uncover new growth opportunities.

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