A 5G Vision for the 4th Industrial Revolution

How 5G will play in this brave, new iteration of the industrial revolution.

By Vicki Livingston

Where we have come from:

- **1st Industrial Revolution – 1760 and the steam engine created factories**
- **2nd Industrial Revolution – 1860 steel, oil and electricity, introduced the light bulb and telephones**
- **3rd Industrial Revolution – 1960's for the Digital Revolution and the introduction of computing**
- **4th Industrial Revolution – Industry 4.0 arrives- 5G mobile wireless technology is a driver**

The rationale for the development of the 5th generation of mobile communications (5G) goes beyond the expansion of mobile broadband connectivity. 5G will provide advanced wireless connectivity for a wide variety of vertical industries, such as the manufacturing, automotive and agricultural sectors, with the massive Internet of Things (M-IOT) comprised of billions of connected devices.

Klaus Schwab, founder and executive chair of the Geneva-based World Economic Forum, published a book in 2016 titled *The Fourth Industrial Revolution* and coined the term in Davos that same year. At the World Economic Forum, January 2019 in Davos, the 4th Industrial Revolution (4IR) was at the center of discussion. It was agreed that a combination of technologies are changing the way we live, work and interact, such as Artificial Intelligence (AI), autonomous vehicles, and IoT. These are among key technologies for societal transformation.

Largely dependent upon advanced mobile wireless communications, the fourth industrial revolution or "Industry 4.0" will usher in the trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things (IoT), autonomous vehicles, cloud computing and cognitive computing (aka, AI). The term "automation" stands for the control of processes, devices or systems in vertical domains by automatic means.

Communication, for automation across vertical domains, comes with demanding and diverse requirements with respect to latency, data rates, availability, and reliability, and in some cases high-accuracy positioning. To achieve this, 5G supports three essential types of communication: enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC), and Ultra-Reliable Low-Latency Communication (URLLC).

Connectivity is a key component of Industry 4.0, which aims at significantly improving the flexibility, versatility, usability, and efficiency of future smart factories, integrates the IoT and related services in industrial manufacturing, and delivers seamless vertical and horizontal integration down the entire value chain and across all layers of the automation pyramid.

Meeting these objectives will greatly depend upon the 5G technical performance such as supporting a peak data rate of 1-20 Gbps; connections density 1 thousand – 1 million devices/km^2; reliability of 99.999 percent (five-nines); enhanced battery life of up to 10 years; higher position accuracy; low latency (1-10 ms); and strong privacy and security.

Key vertical domains and associated use cases with a compelling need for automation include the following:

- Rail-bound mass transit
- Building automation
- Factory of the future
- eHealth
- Smart cities
- Electrical power distribution
- Central power generation
- Program making and special events

Market segments for automation are still emerging and are expected to ignite growth within the next 12 to 30 months. Industry will continue to drive the inflection point with the following key objectives in mind:

- Narrowband Internet of Things (NB-IoT) technologies will help to drive lower costs
- 5G will further enable a new range of opportunities
- New technologies such as blockchain, AI and Multi-Access Edge Computing (MEC) will further overcome technology limitations
- Ecosystem players will move towards more collaborative approaches

Communications in this sphere must support applications for production in the corresponding vertical domain (for example, industrial automation and energy automation, but also transportation). This needs to be incorporated into new security standards and mechanisms for dependable communications.

The 3GPP standards organization has analyzed vertical use cases that resulted in several vertical communication requirements. The well-understood Key Performance Indicators (KPIs) for latency, jitter, reliability, communication service availability, and data rates apply for verticals, as well. In addition, there are other requirements that

should be considered and folded into the potential new service requirements for 5G systems.

Ultra-Reliable, Low Latency Communication

The new services and applications requiring lower latency, better reliability, massive connection density, and improved energy efficiency are emerging in an unprecedented fashion. A variety of advanced features makes 5G uniquely well positioned to meet all of these requirements and capitalize on these market opportunities. URLLC provides a set of features designed to support mission-critical applications such as industrial internet, smart grids, remote surgery, and intelligent transportation systems.

With 4G LTE, latency is currently in the 4-millisecond range under 3GPP Release 14. URLLC is part of Release 15 and has a target of 1-millisecond. URLLC also is ideal for applications that require end-to-end security and five-nines reliability. Moreover, it is almost deterministic in time bounds on packet delivery. This combination of capabilities requires almost a fundamentally different approach to system design and operations compared to previous mobile wireless technologies.

The physical layer is, unquestionably, the most challenging because URLLC must satisfy two conflicting requirements: low latency and ultra-high reliability. This combination is a vastly different type of quality of service (QoS) compared to traditional mobile broadband applications.

As we move to 5G, real-time automation scales out from local compute, to distributed large-scale compute, to mission-critical experience. Ericsson and Arthur D. Little depict the 5G evolution of real-time automation, *Evolution of 5G Real-Time Automation Cluster* (see Figure 1).

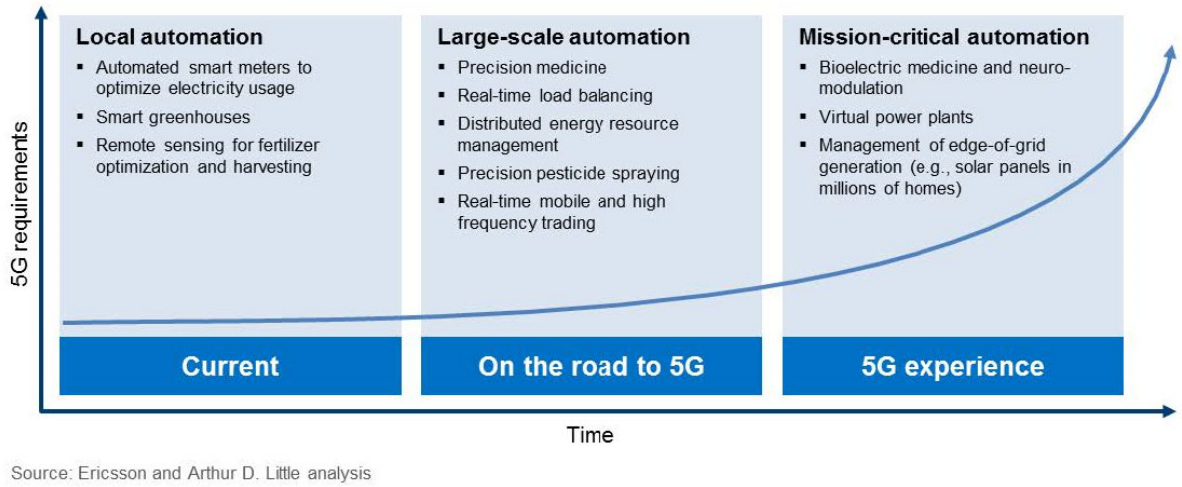


Figure 1. The 5G evolution of real-time automation.

Evolution of 5G Real-Time Automation Cluster

Within Critical IoT applications, monitoring and control occur in real time, end-to-end latency requirements are very low (at millisecond levels) and the need for reliability is great. These performance objectives will be applied to workflows such as the automation of energy distribution in a smart grid, and in industrial process control and sensor networking where there are stringent requirements at the application layer. Security is paramount.

Security in Automation

Security in mobile wireless networks has long been a strong market differentiator against other wireless technologies. 5G takes the security focus to another level.

Industrial IoT security threats include threat actors such as cyber attackers, Bot-network masters, industrial spies and organized crime, terrorist groups, national governments, and insiders. If that is not worrisome enough, the types of attacks include malware-triggered ransomware, network protocol attacks, cryptographic algorithm, and key management attacks, spoofing/authentication attacks, unauthorized endpoint control to trigger unintended control flows, denial of service, data corruption, physical security and access control attacks (privilege escalation). Understanding the source and style of attacks allows for the planning for cyber-security for confidentiality, integrity, authentication, non-repudiation, availability, and privacy.

5G offers new and enhanced capabilities to provide secure solutions, however, in automation for vertical domains these responsibilities are more complex, as they are shared by several actors and need to be managed by credential pairs or certificates from different sources.

- 5G authentication and verification are implemented using the Extensible Authentication Protocol (EAP) framework including native support
- Flexible and efficient subscriber access management (permissions) is important for 5G User Equipment (UEs) that provide communication across automation systems. For example, machinery on a factory floor can be added or removed from the subscription base.
- Devices in many verticals operate over long usage periods (in industrial environments typically 10-20 years). Automation application systems must be easily maintained for this duration without the requirement for physical access for upgrades; it is critical that UEs are upgradable or can be patched (including firmware, security-related algorithms and long-term keys) to keep the devices and systems secure.

- State of the art encryption is standardized in 5G to protect the user plane, control plane, and management traffic; also, 5G supports user privacy protection
- Network slicing provides further security provisions; a dedicated slice can be used for IIoT and protected from malware that may reside in another slice through isolation measures

3GPP Automation Design

Since 2017, Technical Specification Groups (TSGs) within 3GPP have been working on the standardization of 5G systems in the new, vertical application domains involving automated control. 3GPP Release 15 provided a sound basis for automation communications; Release 16 developed normative requirements and the architectural impact to meet these new requirements. Vertical industries are now participating in the development of the standards bringing new insights into how 3GPP technology can be utilized in new industries such as streaming services, A/V production, critical medicine, asset tracking, unmanned aerial vehicles and more. While the application fields of these new studies are different from automation communication, there are similarities in the underlying system requirements needed to meet communication needs. Release 17 will focus on identifying new requirements specific to the applications that go beyond what is already supported in Releases 15 and 16.

New Industrial Vision

First came steam and early machines that mechanized some of our ancestors' work. Next was electricity, the assembly line and the birth of mass production. The third era of industry was the digital age of computers and the beginnings of automation, when robots and machines began to replace human workers on those assembly lines.

Now we enter Industry 4.0, in which computers and automation join in a totally new way. This will bring robotics connected remotely to computer systems, equipped with machine learning algorithms that can learn and control the robotics with very little input from human operators. Industry 4.0 introduces what is being called the "smart factory," in which cyber-physical systems monitor the physical processes of the factory and make decentralized decisions. The physical systems become IoT, communicating and cooperating, both with each other and with humans, in real time via the wireless web.

Considerations for a factory or system to be considered Industry 4.0 include:

- Interoperability — machines, devices, sensors and people that connect and communicate with one another
- Information transparency — the systems create a virtual copy of the physical world through sensor data in order to contextualize information

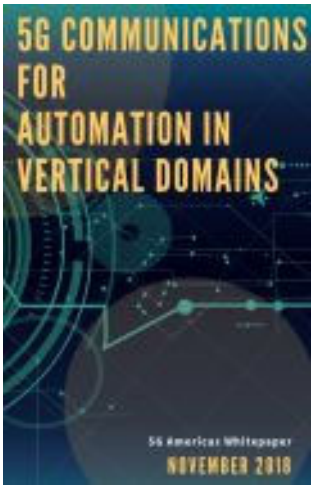
- Technical assistance — both the ability of the systems to support humans in making decisions and solving problems and the ability to assist humans with tasks that are too difficult or unsafe for humans
- Decentralized decision-making — the ability of cyber-physical systems to make simple decisions on their own and become as autonomous as possible

5G mobile wireless technology will offer the opportunity for the Industrial IoT to, effectively and successfully, deliver on a vision for the global fourth Industrial Revolution.

Bio Vicki Livingston, Head of Communications and Analyst Relations, 5g Americas. Vicki Livingston is the Head of Communications and Analyst Relations for 5G Americas and supports the organization's mission to provide a unified voice for LTE and its evolution beyond to 5G throughout the Americas. In her role, she directs all communications, media and analyst relations and conferences for the association as well as strategic planning and liaison with global organizations. Ms. Livingston has over 20 years of experience in public relations and marketing, strategizing and executing the launch of eight new companies or international brands throughout her career, including two wireless companies, 3G Americas which evolved to 4G Americas, and now 5G Americas. Other career experiences include Head of Business Development for not-for-profit organizations as well as one of the largest business-to-business full service agencies in the U.S. She began her career as the first executive level female in the brewing industry as Marketing Manager for Miller Brewing Company, a subsidiary of Philip Morris, Inc. where she first became involved in brand development, market segmentation and supported the launch of the Lite beer brand. Ms. Livingston is an active volunteer having served on Boards of Directors including the Arthritis Foundation, AFS and Easter Seals (Past President). She is an avid sailor. Ms. Livingston earned her Bachelor's degree from the University of Miami in Communications and Business Administration and later attended the Graduate School of Journalism at Marquette University in Milwaukee, Wisconsin, and has academic and philanthropic honors.

Keybox:

Much of the technical information in this article was sourced from 5G Americas white papers that are available on their website for free download.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