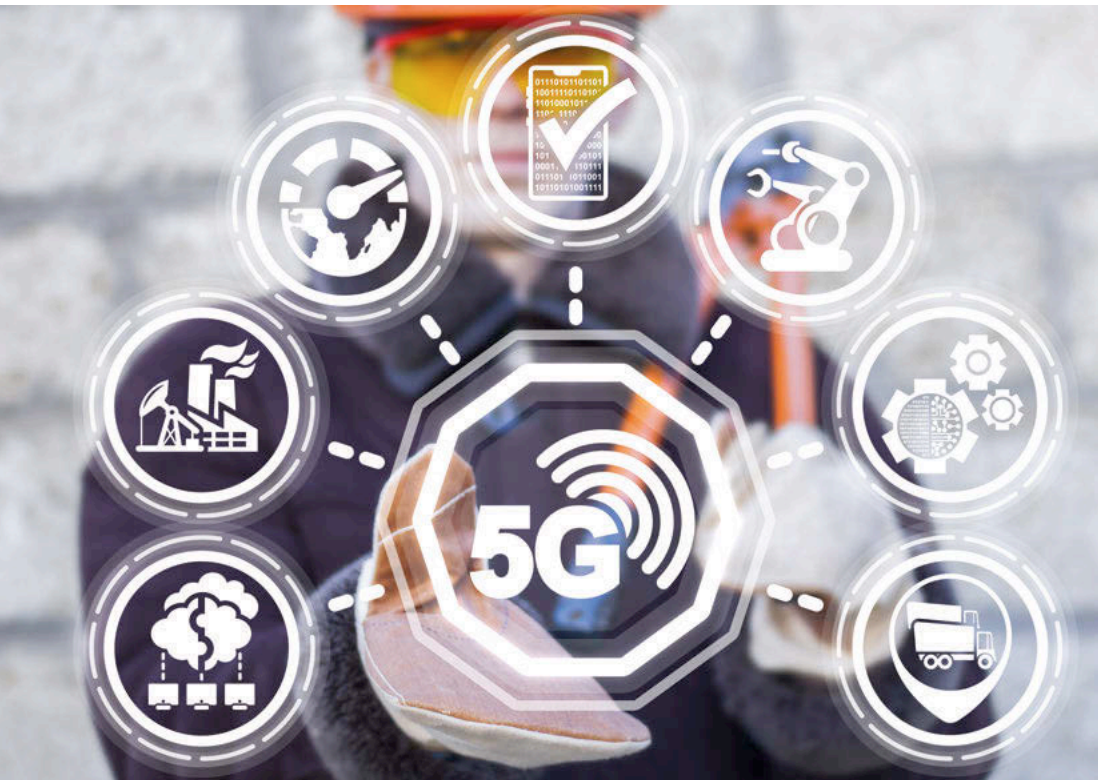
A new era in industrial production?

How can 5G help to unlock the potential of the Industrial IoT? Dr **Yongbin Wei** explains



The next era of industrial production, Industry 4.0, is now upon us, fuelled by advancements in technology such as the rise of big data, automation and cyber physical systems. One particularly significant opportunity for growth within this revolution is the Industrial Internet of Things (IIoT), which covers a variety of applications used in everything from manufacturing, to container ports and power plants. The processes and operating models that make up the IIoT can be elevated to the next level with the high-performance, ultra-low latency connectivity offered by 5G wireless networks.

According to 'The 5G Economy', an independent study carried out by IHS Economics and Technology in early 2017, the full economic benefit of 5G should be realised around the globe by 2035 when a broad range of industries, enabled by mobile technology, could be responsible for the production of up to $12 trillion worth of goods and services. Whether enabling enhanced broadband with fibre-like speeds, mission-critical connectivity with sub-millisecond latencies, or connecting the myriad different devices that comprise massive IoT, 5G is designed as a platform capable of handling a diverse set of services across a wide array of spectrum bands from below 1 GHz up to mmWave and supporting several deployment models from macro to indoor to private networks. A unifying connectivity fabric for innovation, not only will 5G handle the needs of today's industries, but it is forward compatible, with flexibility to deal with services that are yet devised.

Different use cases

Let us consider the 'factory of the future'; a wireless environment in which everything is monitored and optimised. By enabling high-performance wireless communications, 5G offers considerable potential for use cases such as assembly line automation, automated guided vehicles (AGV) decision-making, and the collection of data from sensors to inform machine learning solutions, and AR and VR applications.

What's more, although each of these use cases may have different requirements in terms of speed, latency or bandwidth, 5G is able to handle them as part of a single network.

Depending on their requirements, some use cases can be more challenging and demanding than others. Motion control systems, for example, responsible for controlling the well-defined movements of machines, have very strict requirements regarding latency, reliability, and determinism, while the constant transmission of data within the massive IoT requires high capacity, and the transmission of high-definition video streams to and from augmented reality (AR) devices is heavily dependent on high data rates. The needs of process automation, on the other hand, which employs a variety of different sensors and actuators to monitor and control processes within a plant, sit somewhere between the two. These use cases require Ultra Reliable Low Latency Communication (URLLC), a key element of 5G-enabled wireless connectivity capable of delivering six

nines of reliability at less than 1ms latency, meeting all their needs within a single network.

The factory floor can be a tough environment for wireless communications, however. Blockages and reflections caused by fast-moving metal objects such as cranes and conveyor belts can lead to sudden drops in RF signal strength, and rapidly time-varying interference from the small cells deployed throughout the facility.

Overcoming these limitations and enabling the necessary 'six nines' reliability requires spatial diversity in order to avoid drop-outs and overcome signal blockages.

CoMP for URLCC

Coordinated transmission of signals from multiple antennas in different locations, CoMP (co-ordinated multi point), when enabled by a dense deployment of small cells with high bandwidth backhaul, can provide the spatial diversity and high capacity needed to deliver URLLC's six nines reliability.

By using spatial dimensions to multiplex many data streams, CoMP allows multiple transmissions to be made to multiple locations simultaneously, without interfering with each other, thereby increasing the capacity of a 5G network. In addition, it can allow adjacent networks to share spectrum more effectively.

Finally, spatial diversity can overcome the radio shadowing that occurs in challenging environments such as the modern factory floor, significantly reducing error rates and delivering the URLLC reliability required by IIoT applications.

CoMP requires coordination across several different transmission/ reception points (TRPs) for which functions such as scheduling, and resource management may need to be performed by a centralised unit. Trade-offs can be made though. The physical layer functions could all be moved to a central unit for example, which would support coherent joint transmission CoMP for greater capacity, but this requires high-performance backhaul such as fibre.

Alternatively, splitting the physical layer between a centralised and a distributed unit would support non-coherent CoMP, with less stringent backhaul requirements, such as GbE.

Ultimately, the form that a facility's CoMP network architecture takes will be largely dependent on factors such as its existing network infrastructure, cost and capacity requirements.

Supporting TSN

We are witnessing a trend toward Time Sensitive Networking (TSN) for the wired industrial Ethernet solutions currently driving the IIoT.

A collection of IEEE 802.1Q standards, TSN allows Ethernet to be used for time-sensitive applications that require determinism on both latency and bandwidth which, to date, have been supported by many different open or proprietary implementation using Ethernet or Fieldbus such as Profinet or Ethernet/IP.

Indeed, since its introduction among IEEE standards, the addition of TSN support represents a great opportunity for 5G to augment all industrial Ethernet implementations going forwards.

Its deterministic behaviour relies on time synchronisation, where every node in a network has the same notion of time, which allows pre-allocated timeslots for different flows, and ensures timely end-to-end delivery. Similar to the QoS mechanism in wireless, this "time-aware scheduling" allows best-effort traffic to coexist with high priority traffic although the assignment of slots is based on absolute time cycle rather than just relative priority.

Over time, 5G wireless communication can be expected to replace Ethernet switches and wiring. To operate as a TSN switch, however, 5G needs to address three main aspects.

In addition to carrying Ethernet frames, it must also support "time-aware scheduling" based on synchronous time across the factory, while understanding TSN end-to-end configuration will allow proper resource allocation in order to guarantee latency.

Finally, the 5G infrastructure must be able to convey factory timing not only to UEs (user equipment) but also to the machines that connect to them.

Spectrum allocation

One of the many benefits offered by 5G is that the broader spectrum, both licensed and unlicensed, offers businesses the opportunity to create private networks, optimised for specific industrial applications, and independently managed.

Operators or regional regulators can allocate a portion of licensed spectrum in specific geographical areas, such as at an industrial plant, for example, while unlicensed spectrum can behave like dedicated spectrum when controlled by a property owner in a confined environment. Indeed, in this way, unlicensed spectrum is able to support the demands of the IIoT. With no interference from other networks, for example, a controlled private environment can ensure latency, while using a diverse range of frequency bands can add greater reliability.

These different spectrum options, in addition to capabilities such as CoMP for URLLC or support for TSN, are but a few examples of how the next release of 5G (3GPP release 16) will support the demands of IIoT applications and the challenges of the modern factory floor.

With increased capacity, ultra-low latency, high reliability, and super-fast speeds among its many capabilities, the introduction of 5G will demonstrate what wireless technology can achieve and, in doing so, will unlock the potential of the IIoT and signal a significant step forward in the next era of industrial production.

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