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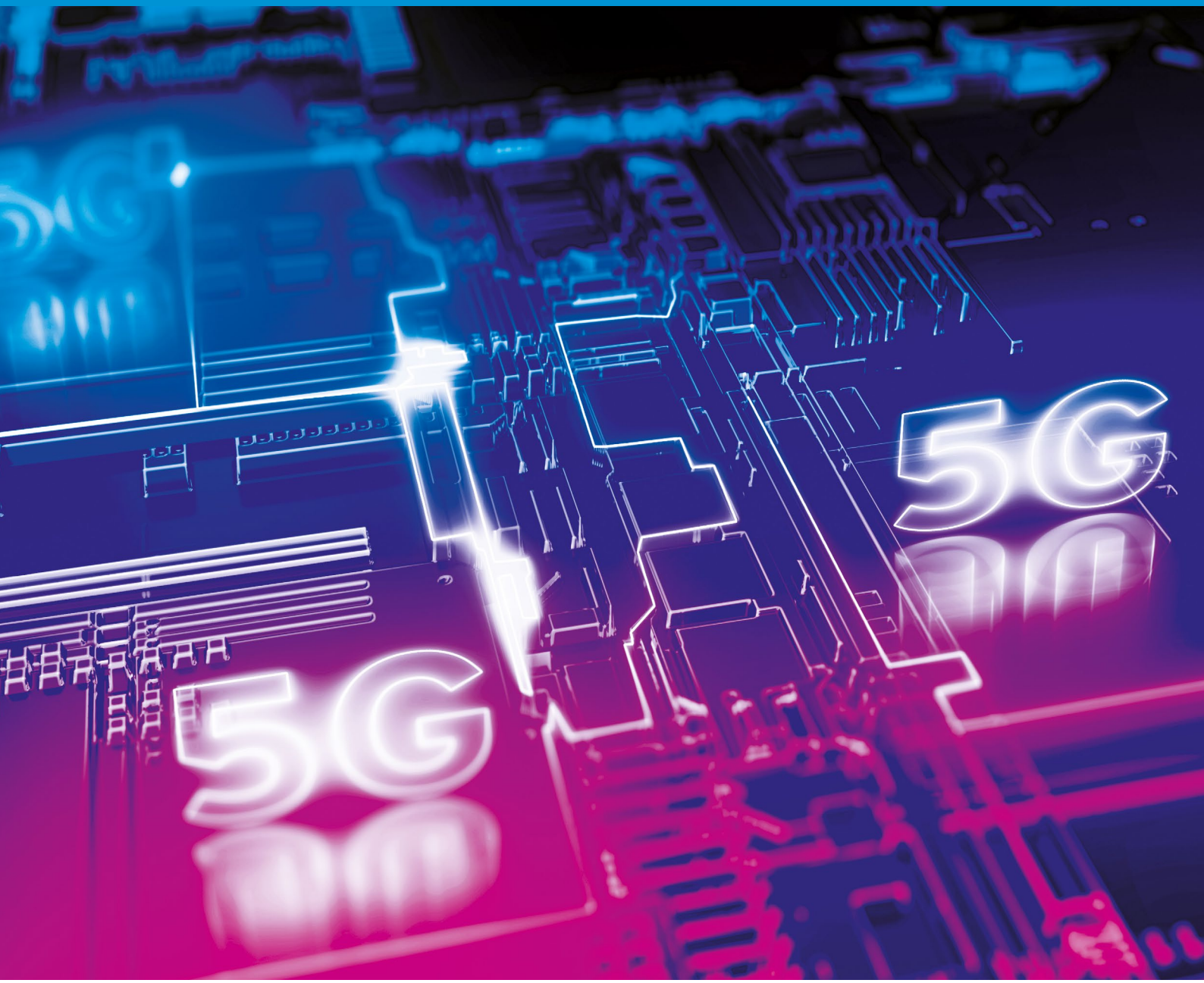
Impact of 5G
on AI and industrial IoT applications



Impact of 5G
on AI and Industrial IoT Applications

We've all seen the hype – 5G is a giant step forward in connectivity, and will be an enabling technology for a huge range of use cases.

No doubt this is true to a degree, though we shouldn't allow ourselves to get swept up as it may be that some of those use cases will be better served by other communications technologies.

That said I am maintaining a seasonally-appropriate spirit of optimism, as I genuinely believe 5G has a substantial role to play supporting other emerging technologies to transform society.

Introducing 'Intelligent connectivity'

5G, AI, and IoT form the basis of what some are calling 'Intelligent Connectivity. This marks the beginning of an era of highly contextualised and personalised experiences, underpinned by ubiquitous hyper-connectivity.

It could impact almost every aspect of our daily lives; from the way we consume entertainment, to the way in which we work and interact with colleagues.

It's all set to give us the information we need, when we need it, making us more productive and efficient. It will change how entire industries innovate and operate, how societies interact and thrive, and how economies flourish.

A few popular examples:

Wellness

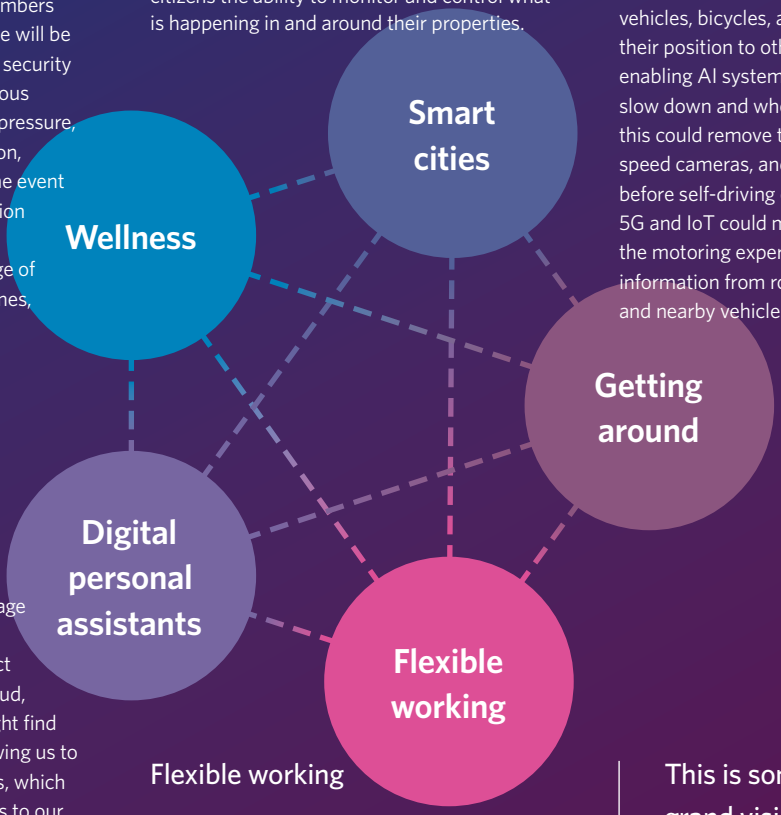
As 5G networks will support large numbers of connections simultaneously, people will be able to wear connected wellness and security monitors routinely, providing continuous information about heart rates, blood pressure, temperature, stress levels, and location, while enabling emergency alerts in the event of a fall or an attack. All this information will help individuals to monitor their personal condition and take advantage of enhanced health insurance programmes, predictive healthcare, and personal security solutions.

Digital personal assistants

Artificial intelligence systems are developing to a point where they can understand and employ natural language to interact with humans. As a result, people will be able to query or instruct a personal assistant hosted in the cloud, regardless of where they are. We might find ourselves wearing 5G headsets, allowing us to converse with our personal assistants, which will be able to respond in milliseconds to our requests for information, while handling related transactions in the background. For example, a business traveller or tourist could ask an AI personal assistant to find and book tables in restaurants, train tickets, and hotel rooms. The assistant would require minimal instructions because it is already aware of the individual's preferences, and even learns as it goes.

Smart cities

Mobile connectivity is already helping buildings and cities to become smarter, safer, and more sustainable. The rollout of 5G will accelerate this trend by enabling deployment of a large number of connected sensors and actuators. These will enable organisations and citizens the ability to monitor and control what is happening in and around their properties.



Getting around

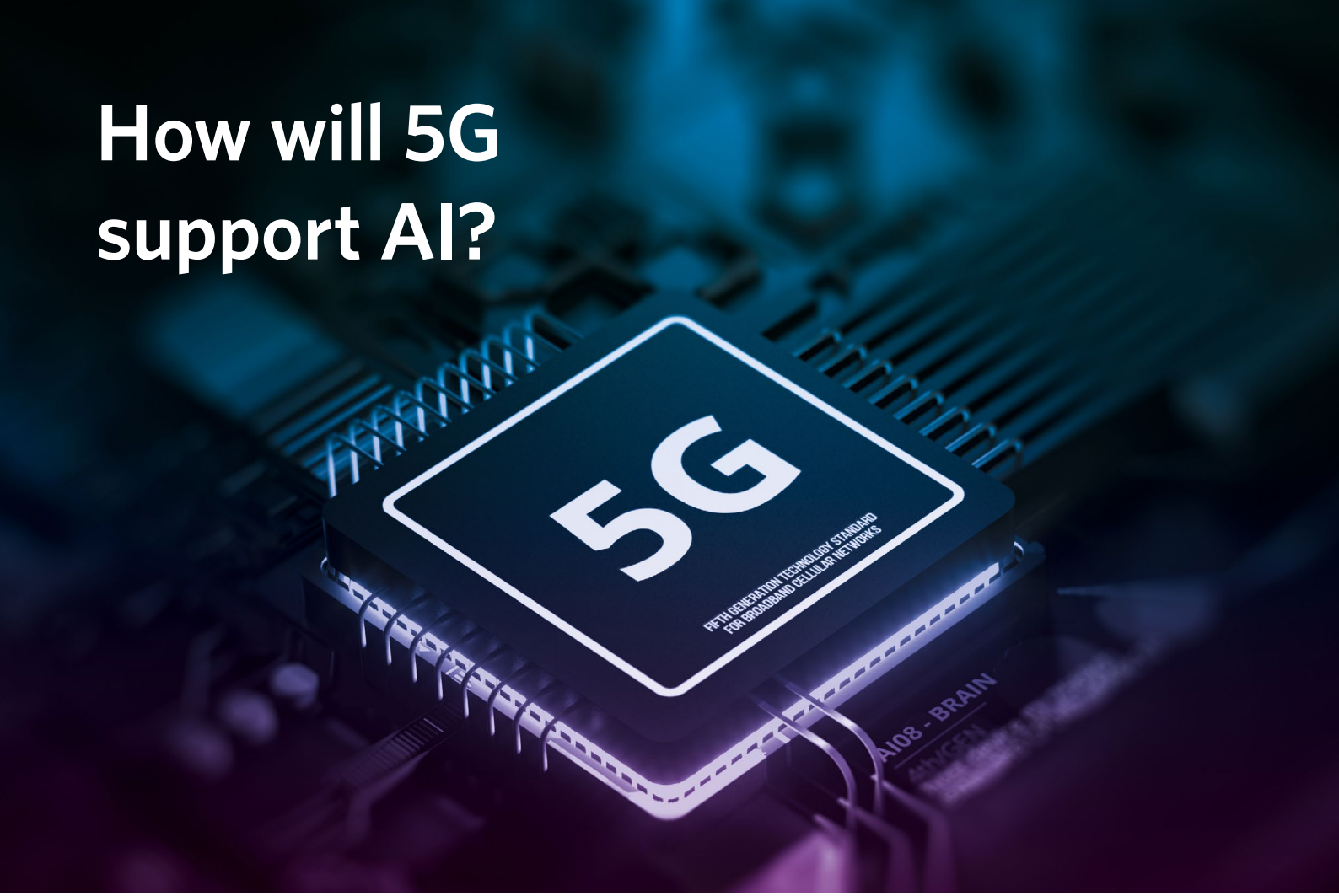
Road transport could become much safer and more efficient if every vehicle can communicate with everything else in the vicinity. Motor vehicles, bicycles, and pedestrians could relay their position to other road users in real-time, enabling AI systems to instruct vehicles when to slow down and when to accelerate. Eventually, this could remove the need for traffic lights, speed cameras, and other street furniture. Even before self-driving cars become mainstream, 5G and IoT could make a major difference to the motoring experience by relaying pertinent information from roadside infrastructure and nearby vehicles.

Flexible working

Intelligent connectivity could enable us to work more flexibly, adapting to the changing needs of business. You could move everything into the cloud to achieve greater agility. You could flex your buildings—renting them in smaller units-by the desk, rather than by the floor. And with the wireless office, you don't have to change your infrastructure when you reconfigure. You'd have the ability to deploy and redeploy working spaces in a much more flexible way. Not to mention improving resilience by enabling worker productivity even if getting to the workplace proves difficult for any reason.

This is something of a grand vision of the future, but we can already start to examine how these emerging technologies could work together to bring it into reality.

How will 5G support AI?



Stepping it up

5G is set to deliver huge bandwidth, millisecond latencies, and reliable connections. This allows us to shift computing between devices and the cloud to optimise how networks and computing resources are used, which will support AI processing.

Because 5G gives better faster access to the services operating on the cloud, it brings information, computing power, and the user, closer together. The impact of this is that the service 'feels' more local to the user, whilst at the same time the AI is able to access and process the user's data faster. 5G's low latency, together with AI's decision-making capabilities, will combine to enable smart devices to respond in real time to a changing operating environment.

5G can support up to a million concurrent edge devices per square kilometre, which is an order-of-magnitude greater than 4G technology. That 'last mile' scale will enable businesses to collect vast amounts of data continuously from 5G-equipped devices in an emerging paradigm known as multi-access edge computing, also known as wireless edge computing.

As 5G networks begin to flood data streams everywhere with fresh data from devices, it will enable AI data lakes to be replenished in real time enabling more sophisticated analytics and machine-learning models for real-time applications.

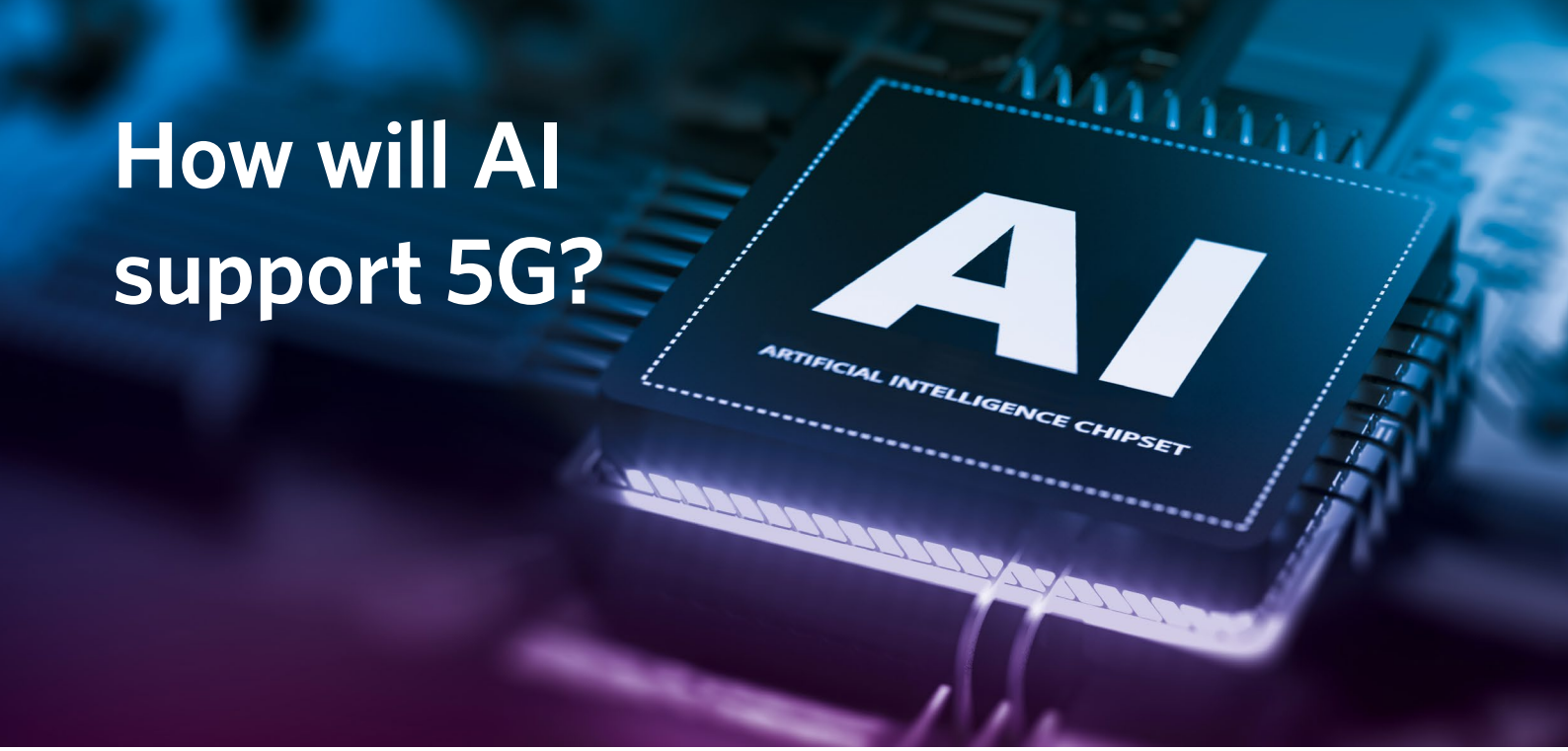
Living on the edge

Wireless edge computing is the shifting of intelligence from the 'central' cloud to a complementary combination of: (i) edge cloud; and (ii) on-device intelligence. Essentially, it's about moving compute resources to the servers that interact directly with the edge devices, as well as to the edge devices themselves.

These edge devices might be those found in the home (tablets and other personal devices, gaming rigs, and domestic smart devices), those found in industry (secure access devices, sensors, and industrial automation), or those we use on the move (such as mobile devices, vehicle control systems and infotainment, and wearables).

By putting the computing resources on the device itself, we can enhance security, as well as privacy compliance, by keeping data local. It also allows customisation and personalisation of the applications, and gives the user autonomy. It gives immediacy by operating tasks at the device level, and it makes efficient use of bandwidth and spectrum, which are finite resources. On-device processing is complemented by processing at the edge of the cloud, which augments on device capability with scalable processing power. This allows service providers to deliver added-value services.

How will AI support 5G?



The rise of AIOps

In all likelihood, the main way that AI will support 5G is in AIOps. That is, embedding intelligence into network operations.

Firstly, we know there is going to have to be a lot of investment to make 5G work. Purchasing spectrum will come at a significant cost to service providers and, on top of that, key investments in core and radio access networks as well as hardware updates will be needed to account for the greater cell density and tower infrastructure that's required for 5G to function. AI can help to keep running costs down as a method of softening the blow. AI could enable the end-to-end automation of processes in a scalable way, and so could be used to reduce overall running costs resulting from process inefficiencies.

To serve the next generation of distributed AI applications effectively, 5G networks will need to become continuously self-securing, self-repairing, and self-optimising—basically, they need to be able to look after themselves. This, in turn, relies on AIOps to take control of application-level traffic routing, quality-of-service assurance, performance management, root-cause analysis, and other operational tasks. And it's going to have to do this more scalably and efficiently than manual methods alone.

Optimising limited resources

AIOps will drive differentiated quality-of-service across 5G environments (in conjunction with network slicing, discussed below). AI-based controls will ensure that radio-frequency channels and other infrastructure resources are provisioned dynamically to support changing quality-of-service requirements, traffic patterns, and application workloads. They will also support continuous configuration and reconfiguration, and proactive subscriber experience optimisation.

When talking about resource allocation, this includes 5G's dynamic RF-channel allocation. As a rule 5G uses smaller cells than 4G, reuses frequencies more intensively, and must continuously retarget the antenna for each edge device This is because it uses beam-formed phase-array millimeter-wave antennas to communicate with each edge device.

To ensure quality of service, 5G base stations dynamically predict and provision the best wireless path to each device. Because of the high frequency mm-wave spectrum being used, the signals are readily attenuated by walls and other solid objects, and so the base stations will need to account for this in provisioning optimal network paths. This will need real-time analytics to perform the necessary calculations, and it will then make the constant changes necessary to give the most efficient local loops.

How can Communications Service Providers benefit?

In order to make the most of the opportunities, communications service providers will need to take a proactive approach. This could include:

- building standardised interfaces to enable AI access to relevant and actionable data;
- exploring ways of using AI to optimise customer experience;
- running early trials to identify ways of using AI to deliver new services;
- examining use of AI and automation for network operations, including planning and optimisation; and
- being early adopters of new solutions using AI and automation to facilitate the development of new use cases.

Network slicing

One of the key enabling technologies that will allow us to reap the rewards of 5G connectivity is network slicing, which allows operators to 'slice' one physical network – including the device, RAN, backhaul, and core network – into multiple end-to-end networks. We create several virtual networks over a common shared physical infrastructure.

Firstly, 'Network Function Virtualisation' takes all the physical network resources and abstracts them into virtual networks. Those networks will be software-defined, which separates routing and forwarding to optimise the performance of the network. Orchestration will then allow end-to-end management of each slice. This allows us to optimise the networks for specific use cases, in terms of protocols, quality of service, latency, availability, and security settings.

Spectrum is a costly and finite resource, and it would be very expensive or simply impractical to build different physical networks for each use case, so network slicing makes investment in physical infrastructure much more commercially viable. This is a paradigm-shifting technology, and it would be hard to justify the massive global investment in 5G infrastructure without it.

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Network slicing continued

*"Cellular networks today are optimised for the type of data that is processed through your mobile phone, but actually there are **three** fairly distinct scenarios we might look to serve through network optimisation."*

eMBB enhanced mobile broadband	Provides higher speeds for applications such as web browsing, streaming, and video conferencing. Emphasis on high bandwidth (Gbps), with good latency (<10ms), But availability is less important (99.9%).	UHD video, gaming, XR. **Automotive:** Infotainment. **Media:** Programme-making and special events. **Healthcare:** Remote surgery.
URLLC ultra reliable low latency communications	Enables reliability for mission-critical applications that require near-zero delays in data transmission. Emphasis on high availability (99.9999%) and low latency (<1ms), with bandwidth in the mid-range (Mbps-kbps).	Mission critical IoT, public safety, industrial automation. **Automotive:** autonomous vehicles, road safety features. **Energy:** communications between power grid substations and control centre. **Healthcare:** Patient health monitors.
mMTC massive machine-type communications	Supports a huge number of devices with low individual bandwidth and availability requirements. Availability can be important (99.99%), but bandwidth per device is typically low (kbps), and latency is unlikely to be an issue (<100ms).	Sensor grids. **Automotive:** telematics, navigation. **Energy:** Smart metering. **Healthcare:** Non-critical personal health monitors.

By being able to individually service the particular needs of specific industries, telecoms operators could transform from being simply a connectivity provider to being an important business partner for a variety of industries. Business models will need to be developed on a 'per slice' or 'per service' basis, so could end up being pretty diverse. It will be interesting to see what new business models will be developed to enable partnerships between telecoms and non-telecoms players.

Thinking about legal and regulatory aspects, and taking a helicopter view, network slicing is not expected to cause any shifts in the current regulatory regime. The principles and practices of net neutrality, illegal content, quality of service, and cross-border data transfers are not expected to change. Having said that, if network providers are going to shift their business models to take advantage of the opportunities that network slicing presents, this will require organisational change and they will need to adapt their approaches. This will mean that counsel advising these businesses will be dealing with a different set of legal challenges to the ones they may be used to.

Privacy and security are also critical and become challenging when the slice crosses between spheres of control, and Ofcom are likely to face a difficult task. Different infrastructures will have different security levels and policies since those are managed and administered by both telecom and non-telecom players. The new Telecoms Security Bill, once introduced, will also likely have an impact here.

How will 5G and AI impact on industrial IoT?

Intelligent connectivity is set to drive Industry 4.0, in which robots and computers continually optimise production and maintenance in highly flexible factories and plants.

The McKinsey Global Institute concluded that AI and big data are not only contributing to the transformation of society but, as compared to the Industrial Revolution (Industry 1.0), this revolution is happening ten times faster and at 300 times the scale – therefore totalling 3,000 times the impact.

The application of 5G to Industrial IoT, along with AI, machine vision, and robotics, is going to lead to new operating models that are safer and more efficient.

A key indicator of efficiency of a production line is the amount of time it is not producing anything because it is waiting for something to happen: the 'cyclic idle time'. The productive (non-idle) portion of each cycle then reflects the efficiency of the line.

Manufacturers use heuristic line balancing techniques to determine the allocation of tasks so as to maximise non-idle time whilst minimising labour costs. These techniques determine the allocation of tasks to lines based on a pre-specified throughput.

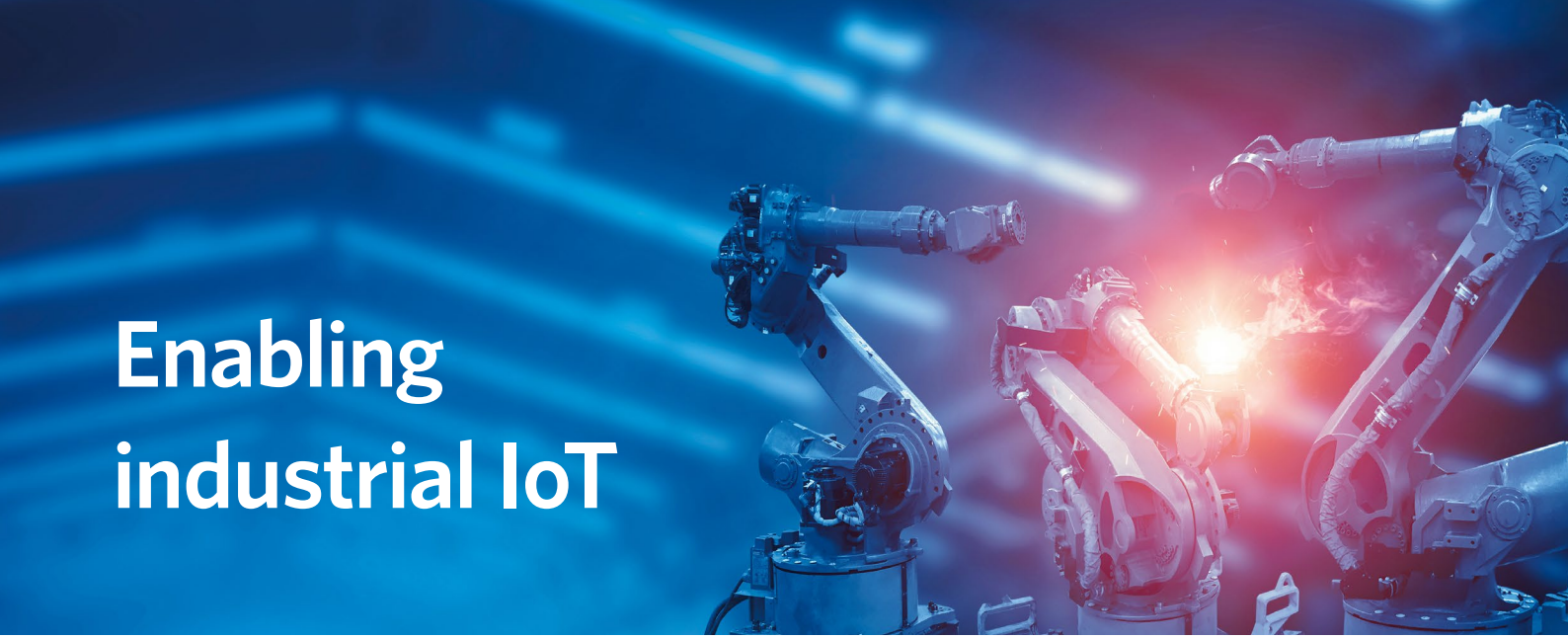
When demand or supply changes, lines may have to be reconfigured to reflect the new desired flow rate. With Industrial IoT, we can envision reconfigurable production lines that are adaptable to changing requirements.

Industry 4.0 will be characterised by self-optimising production facilities that process a continuous flow of information to automatically adapt to events. This could be a supply shortage, signs of a potential machine fault, or a new customer requirement.

If necessary, specialist machines will even be able to produce parts on-demand using additive manufacturing techniques, enabling the replacement of broken components and reduction of costly downtime.

From a safety perspective, sensors will communicate with motion controllers to enable robot motion control that is more dynamic and responsive to context. The enhanced precision that the addition of intelligence will bring will make these robots safer for those working near them. We can also expect to see an increase in the use of mobile robots, automatically guided vehicles, and drone technology.

Enabling industrial IoT



Finding the right path

It's likely that 5G will help deliver ultra-reliable and low latency connectivity to industry through private networks using licensed and unlicensed spectrum; wireless edge computing; time sensitive networking; and network slicing, allowing specific services to be prioritised. By capturing information in real-time and enabling remote control of machinery, factory-wide connectivity can increase efficiency and enhance the value manufacturers can provide to customers.

Delivering ultra-reliable low latency connectivity may be a particular challenge in industrial environments where there are a lot of metal objects which can disrupt wireless connections. However techniques have been developed to overcome these challenges, with a combination of wired connections and co-ordinated multi point (CoMP) wireless network architecture. CoMP uses a high density of cells with spatial diversity to minimise packet loss arising from attenuation of signals by obstructions. In other words, if we take a lot of cells and spread them around, then there's always going to be a clear path to the target.

Private networks

The use of private networks will allow the operator a dedicated, highly optimised, and secure digital environment in which to operate. 5G will be vital for real-time applications where millisecond and microsecond latency is required, such as extended reality (AR/VR/MR), closed-loop robot control, and automatically guided vehicles. It will use a combination of licensed and unlicensed spectrum bands.

Access to the unlicensed bands will be pretty hassle-free, and to the extent licensed bands are needed for the application, it's likely this will be on the basis of shared or sublicensed spectrum. Depending on the precise application and the particular challenges presented by the environment in which the network is to be deployed, it may be appropriate to use LTE/4G alongside 5G – particularly for applications requiring lower bandwidth and non-time-critical applications where higher latency won't cause problems. For example, for product tracking and diagnostics.

Operators in the UK can currently sub-license LTE/4G spectrum under Ofcom's spectrum policy to release unused spectrum and increase industrial usage. This helps the UK to compete with other countries in deploying industrial spectrum usage. LTE spectrum is also available in Europe (with Germany pioneering this in particular) as well as in the US (which uses the CBRS band).

A matter of time

Because the reliability of data transmission has historically been more important than when the data arrives, IT networks typically have no concept of time. Under time division multiplexing for example, packet data will be delivered in the next available slot. The IEEE is developing a set of standards for Time Sensitive Networking, which is largely an extension to the 802.1q standard for the transmission of time-sensitive data over ethernet networks.

These standards focus on giving all devices: (i) a common understanding of time; (ii) common rules for processing and forwarding communication packets; and (iii) a common model for selecting communication paths and reserving bandwidth and time slots. They also contemplate using more than one simultaneous path to achieve fault-tolerance. This will be particularly important for machinery control systems, safety-critical mechanisms, and autonomous vehicle control, where a failure to get data through on time could prove fatal to somebody.

Time sensitive networking can be also used in Industrial IoT to implement other systems that must react quickly to changes in the environment, such as enhanced dynamic robot motion control, as well as allowing machines to be time synchronised to improve efficiency.

Conclusion

I began this article by recognising the hype around 5G, but to me its clear that there is real substance underlying it. In my view 5G will play an important role not just in and of itself, but as an enabler of other enabling technologies (such as AI and IoT). Ultimately, it will be down to those of us working in the sector to bring it to life and seize the transformative opportunities these innovations offer.

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