A new perspective for industry:

The pervasive intelligence of evolved intent-based networking

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Contents

Executive summary

The traditional approach to communications networking isn't cutting it. Incessant demand for high performance connectivity across industries has left it struggling to scale up and handle the increasing levels of configuration and adaption required. Something has to give. The role of intent-based networking (IBN) is under the spotlight as the capabilities of enterprise IT, private and telecoms networks rapidly evolve. But even here, the ability of this process to enhance agility, efficiency and security is compromised. We are proposing a better way.

Cambridge Consultants is a global team of 800 scientists, engineers and technologists with a collective vision of a future unconstrained by current thinking. We believe tough industry challenges demand bold, ingenious solutions – which is certainly the case here. In this paper, our AI[1] and telecommunication[2] teams present our concept of 'evolved IBN'.

We consider it to be the biggest opportunity for the networking arena since the internet. By expanding the boundaries of what's currently considered possible, evolved IBN can deliver new capabilities and revenues for network users and operators across a variety of industries, including agriculture, healthcare, logistics, manufacturing, ports, utilities and warehousing.

Essentially, IBN is a software-enabled process that configures infrastructure on the basis of a business intent. In its current centralised form, this method of network administration incorporates artificial intelligence (AI), network orchestration and machine learning to automate administrative tasks from a centralised point on a network. The goal is to simplify the creation of generating, managing and enforcing network policies and reduce the manual tasks associated with traditional configuration management and network operation assurance.

But there's no doubt that this conventional form of IBN has limitations. The problem is that it does not draw on intelligence from all the devices or nodes that are connected to the network. Our concept of evolved IBN, on the other hand, does just that – utilising pervasive intelligence from across the entire network. This means it is able to deliver truly holistic and comprehensive network administration.

How is this possible? Multiple, fundamental technological capabilities are arriving simultaneously to fire the potential of evolved IBN. AI, open radio access networks (Open RAN), private networks, software controlled and defined networks, network functions virtualisation, plus 5G, network slicing and an abundance of IoT and industrial applications place new demands on the network. Yet they simultaneously make new capabilities a reality.

The upshot is that the network must transform radically in order to optimise secure, reliable transmission. To achieve this, a highly advanced and automated form of evolved IBN needs to be adopted which derives insights from the pervasive intelligence we've described. This will result in new capabilities that lead to novel service offerings alongside greater robustness and resilience.

This invention of new networking certainties promises substantial opportunity for everyone involved. The ability to flexibly initiate evolved IBN to address a specific business need – and for the end customer to have complete confidence that a specific service and experience level will be delivered – is compelling. Not to say transformative for industry.

The promise, then, is enormous. But achieving this potential will be complex and demand tools, experience and sector knowledge to turn a conceptual ideal into a positive contributor to the bottom line. We are now going to set out why evolved IBN is difficult yet attainable. We'll also explain why network owners of all types – as well as their enterprise customers or users – should take notice. And we will identify those who can benefit from the commercial opportunities that evolved IBN will make possible.

[1] Cambridge Consultants. (2022) Telecommunications. www.cambridgeconsultants.com/markets/telecommunications
[2] Cambridge Consultants. (2022) AI and Analytics. www.cambridgeconsultants.com/expertise/ai-analytics

1 Introducing evolved intent-based networks (IBN)

An IBN is a method of network administration that uses AI to automate network configuration to support a specific set of business requirements that are then formalised into specific intents for the network to carry out. Evolved IBN can simplify and accelerate the creation, management and enforcement of network policies while eradicating manual network configuration processes. The objective should be that, on receiving a description of a desired business outcome, the network converts it into a network configuration that enables the result to be achieved without the need for individual tasks to be coded or executed manually. With pervasive intelligence, the evolved IBN can dynamically resolve conflicting requirements placed on the network and ensure the most critical intent is prioritised.

This concept of pervasive intelligence, on which evolved IBN relies, is achieved by gathering comprehensive points of information at volume from distributed locations across the network. Deep learning and machine learning methods are then applied across the network to extract insights from the intelligence so the evolved IBN system can act upon these and set up the network to meet business requirements. Our internal research and development work has indicated the feasibility of this approach and we can predict network traffic and associated latency demands using deep learning methods. We see this new capability, which proves the feasibility of the concept, opening up the potential to apply evolved IBN to use cases from across a spectrum of industries.

Ultimately, pervasive intelligence means that the network has been made more resilient because relying on multiple sources of intelligence eradicates the traditional baked-in reliance on a single point of failure. It is the ability to orchestrate the functions of an IBN across multiple networks, network nodes (any electronic device that is attached to a network, and is capable of creating, receiving, or transmitting information over a communication channel) and edge devices that is the transformative capability being unlocked today.

In practice this means an item of network equipment can detect when another is overloaded – or looking likely to become overloaded – and can re-route traffic away from it to alleviate the pressure on service delivery. This has a knock-on effect in relation to other devices and how intelligence is applied to their operations because re-routing traffic to another device can increase pressure on the second device. Evolved IBN addresses this because its insight is comprehensive thanks to its intelligence being pervasive.

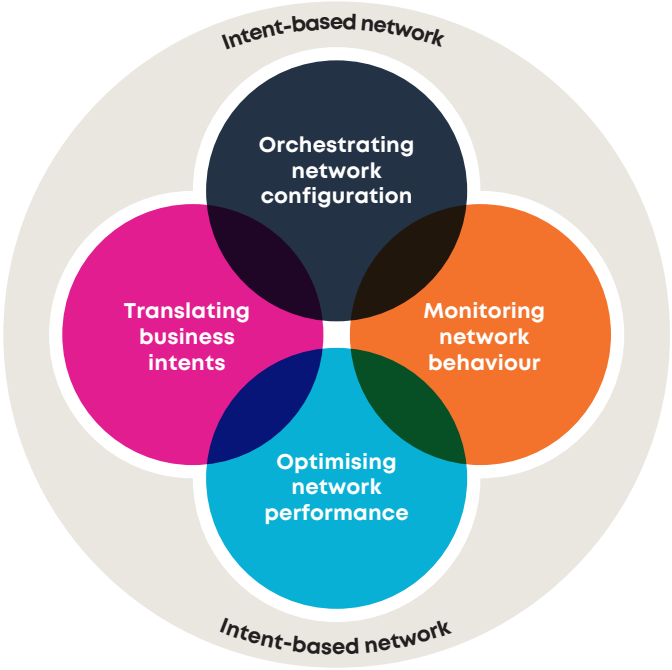


Figure 1: A definition of what an intent-based networking system incorporates

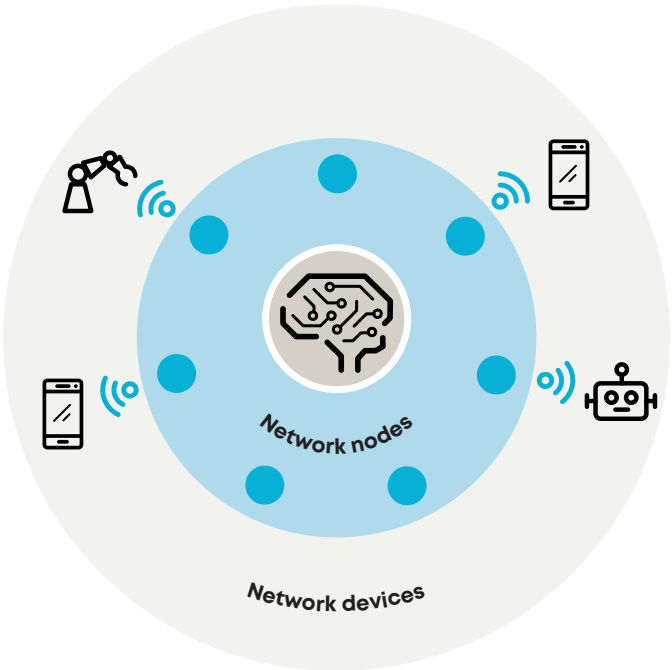
How will organisations benefit?

A good example is an intent that states a secure tunnel – an encrypted link between one network and another – is needed between two points. In this scenario, a network provider would identify which traffic should use the tunnel and set out its basic capabilities, but it would not go into the specifics. Traditional considerations such as how the tunnel would be implemented, the number of devices to be used to enable it and the specific parameters to be initiated are not addressed because an IBN automatically generates the complete configuration based on the service description, which the IBN knows from catalogue information that it uses to configure the service. It then provides continuing assurance checks between the intent and the actual, operational state of the network to ensure it is still configured correctly.

Exciting applications and inventions rely on evolved IBN to ensure the characteristics they need from the network are available. This encompasses all aspects from security to resilience to powering data analytics and enabling digital twins. Critically, IBN separates network configuration complexity from the business intent, enabling plain language requests to be made. This in turn allows network features and functions to be enabled flexibly, automatically and at scale in support of use cases that previously would not have been viable because of the costs of non-automated configuration, operation and orchestration.

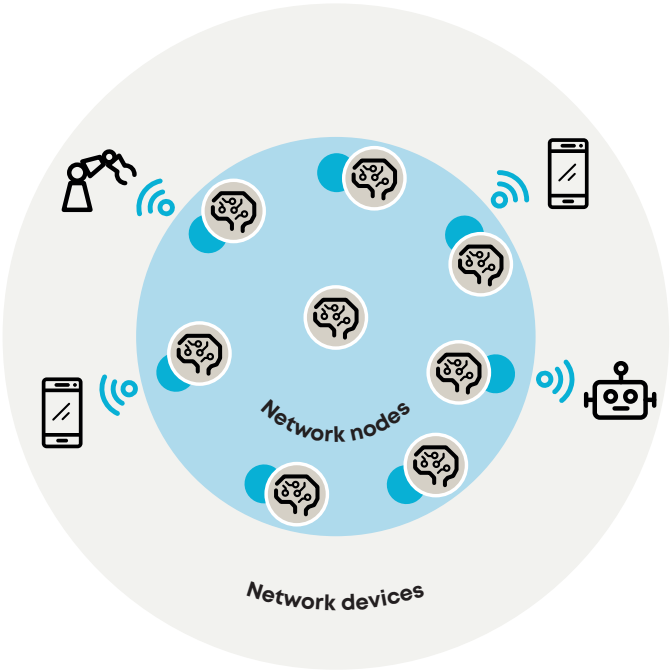
"Exciting applications and inventions rely on evolved IBN to ensure the characteristics they need from the network are available."

Intent-based network



- **Centralised intelligence**
- **A single view of the network**
- **A single point of failure**

Evolved intent-based network



- **Pervasive intelligence**
- **Enables a 360 degree view of the network**
- **Single points of failure eliminated by redundancy**

Figure 2: A comparison between a legacy intent-based network and an evolved intent-based network

Future services will make highly-specific network demands

These will vary from the guaranteed uptime demanded by medical devices and robots to function-oriented performance needed by manufacturing equipment within a private network or machines and automated guided vehicles (AGVs) in warehouses or factories. Some applications or use cases demand reliable, safety-critical networks while others are looking for the ultimate in optimisation in order to enable thin margin business cases.

An evolved IBN can be indispensable in supporting efficient operations of robots on what is effectively a warehouse floor. AGVs, picking machines, weighers and conveyors all need to come together with connected systems that ensure stock is sent to the right locations and customers' shops are handled efficiently. This example encompasses a multitude of intents within a single business and IBNs can be established to enable functions for this disparate array of intents.

These start with identifying the business intent – in this case to achieve optimised stock picking across a warehouse – and then translating this intent so a script is coded that can configure the hardware and control bandwidth during the picking cycle. Then the evolved IBN system runs a feasibility check before approving the configuration changes and authorising them to be implemented. As before, performance is constantly audited and the configuration is adjusted, ideally by AI in real time to assure performance. Finally, the evolved IBN system reports the network status, performance and any issues to the network administrator. All of this is done automatically, thereby simplifying network configuration and operations to a degree previously unheard of.

Evolved IBN should therefore be looked upon as a refinement of automation that further simplifies network configuration and optimisation. This simplicity is essential if many of the future use cases of Internet of Things (IoT) and 5G are to be achieved. Evolved IBN has an important role to play here because it addresses the need for organisations to be able to set up a specific network to manage each of their applications or services in an optimised way. Without this capability, organisations will not be able to configure networks efficiently and automatically and in ways that the business, service or model they want to introduce is viable.

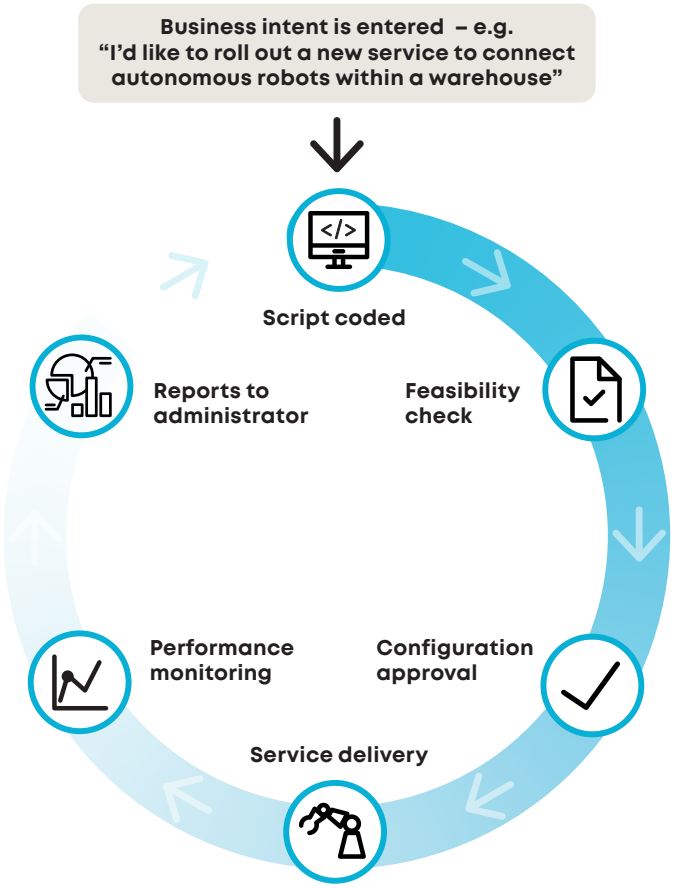


Figure 3: How an intent-based network can configure itself to deliver a service that supports a specific business intent

"Evolved IBN should therefore be looked upon as a refinement of automation that further simplifies network configuration and optimisation."

2 The ingredients that make evolved IBN work

Evolved IBN is fuelled by intelligence it accesses from devices that are distributed across the network. This is in contrast to static IBN which is limited by the centralised nature of its intelligence sources. Evolved IBN is an advanced concept that moves static IBN to a new, dynamic era in which intents are constantly altering based on network demand and the demands of business requests.

Pervasive intelligence

Centralised intelligence provides only a single source of static data and is not sufficient to enable IBN because insight is needed into all the continuously changing network information in order to enable delivery of an intent. Pervasive intelligence that extends down to the individual device level is essential so the network can ensure it is acting on the correct intelligence at all times. While some types of network-level intelligence may be considered to be relatively low-grade, this becomes valuable when intelligence from multiple sources is consolidated to enable a complete picture to be created. The granularity of information available is increased because intelligence from a network node, for example, is sensitive to inputs of information gathered from other nodes which means that nodes have empathy for each other.

Empathetic nodes that route traffic dynamically are suddenly no longer an abstract Sci-Fi concept and are close to becoming a mainstream reality. All the barriers are set to be addressed by solutions that are in development or by refinements that are already underway. The application of deep learning and machine learning is enabling us to predict quality of service within the network and we are continuing to work to enable prediction of quality of experience.

In addition, we have deployed complex detection algorithms on edge devices to add further intelligence to the IBN landscape. The growth in intelligence at edge devices enables more complex AI models to be deployed through the network and, with greater compute resources at the edge, more intelligence and information will be transmissible to feed IBNs' needs for pervasive intelligence.

"Evolved IBN is fuelled by intelligence it accesses from devices that are distributed across the network."

Analytics for situational awareness

The awareness of their surroundings and of what the network is doing at a specific time demonstrates the difference between IBNs and traditional networks. If you think of a traditional network as an unskilled soccer player simply looking to receive a pass and then play their next move, an evolved IBN is a highly-experienced player that has 360-degree awareness and has already planned the next series of moves based on what team-mates are doing, where they are positioned and how the opposition is behaving.

This awareness of the evolving game-play means an evolved IBN's response to the user – whether a machine, a human or a network – is to deliver a better experience of the network where feasible or required. Utilising this intelligence and the insights contained within it results in the evolved IBN being able to act like a canary in a mine providing an early warning of gas or, in the case of evolved IBNs, detecting unusual usage patterns to highlight distributed denial of service (DDoS) attacks and other anomalies that identify threats or frauds.

What has changed to make evolved IBN possible?

Evolved IBNs rely on a combination of computational power, data analytics and processing and algorithms to achieve intelligence and enable automated orchestration of the attributes required by an individual network. These complex capabilities are now maturing to the extent that they are widely available and, at roughly the same time, semiconductor technology has continued to improve alongside edge computing capabilities which allow intelligence to reside at each edge device. This distribution of information across edge devices means evolved IBN has many more potential sources of information to inform its decision making.

Edge is an amorphous term that can be fitted to various use cases up and down the value scale, but it is now possible to run simple algorithms on edge devices to ensure insights and information are accessible to the evolved IBN. This accessibility will help to make evolved IBN pervasive. In addition, the ability to respond to changes in order to multiply redundancy across a network is now in place and this further widens the applicability of IBNs.

This effective early-warning system can also be applied to learning about bottlenecks and congestion, such as the classic mid-afternoon internet capacity crunch when everyone is online. The evolved IBN should be able to learn to aggregate data from all of the situations it is aware of and then address what is happening. A combination of policy coming down, anomalies going up and awareness of standard traffic patterns fuels evolved IBN intelligence and enables it to ensure smooth operation and to assure quality of service.

Orchestration

The ability to orchestrate the functions of an evolved IBN across multiple networks and edge devices is the transformative capability that is being unlocked today. Evolved IBNs' ability to provide the insights necessary for networks to be orchestrated to improve network operations and uptimes and assure quality of service and experience is how the business value of IBN is expressed.

The ability to do this in an automated way that eradicates the complexity of traditional operations is an important evolved IBN value proposition because, once a business outcome is described, the network configures itself to achieve the necessary objectives. This is the essential capability for the dynamic, software-controlled networking world and the reason so much attention is being devoted to evolved IBN at the moment.

Why evolved IBN is needed

Evolved IBN is needed because the potential number of intents handled by network has increased significantly. Far from the early stages of networking in which there was just a single service and, more recently, a tightly constrained portfolio of just a few voice and data offerings, there are now multiple different devices seeking connections to networks, often for highly specific purposes. We are seeing these connections used for enabling vertical market-specific enterprise services with greater frequency and, although private networks are leading the adoption charge today, we see evolved IBN as an opportunity that is open to all.

Network cost and congestion present challenges to many future – and some current – use cases so better capacity utilisation is a goal for all organisations. Sometimes maximising capacity utilisation is focused on making networks affordable for specific applications while for others it's simply about good operational practice or ensuring lower latency connectivity is available. In general, IBN provides a pathway to ensuring network capabilities can be provided at a sustainable cost with assured quality of service and experience. This sustainability is essential to the use cases of the future which also depend on the simplified management, automated configuration and maximised capacity utilisation that IBN supports.

"Evolved IBN is needed because the potential number of intents handled by network has increased significantly."

3 What innovative services does evolved IBN enable?

IBN capabilities are limited only by the imaginations and intentions of network users. Everything from operating thousands of robots in a warehouse, to instantiating a secure tunnel for a limited time is an intent.

The near future involves massive opportunities and huge volumes of individual intents that will need to be addressed. This is becoming possible thanks to new capabilities in multi-access edge computing (MEC) and ultra-reliable low latency communications (URLLC) in 5G, which also brings massive connection density per cell and enormous bandwidth. Add to these AI plus the data discovery and analytical capabilities and a vast array of new intents can be made real.

In addition to the secure tunnel and warehousing examples mentioned earlier, we also see examples in healthcare where medical support for chronic conditions can be achieved over LTE or 5G networks that monitor, record and then communicate vital signs to hospitals or medical professionals. The intent here is that the network is available to the system when it needs to upload data but does not unnecessarily connect and consume battery power when communication is unnecessary.

Another low-value example is soil sensors in a field of crops. These can communicate pH levels, soil moisture or the need for fertiliser. As they are numerous and typically cheap products that seldom communicate urgent data, the network needs to be configured to reflect this. For applications of this type, maintaining low operating cost is important in order to secure high volume uptake to make the service proposition viable for its service provider.

Higher-value examples are apparent in the utilities industry where power suppliers, for example, could utilise evolved IBN to support their advanced metering infrastructure (AMI), supervisory control and data acquisition (SCADA) systems, distribution automation and distributed energy resources. In AMI alone, having IBN-enabled capabilities would enable the network to be built for purpose and smooth out peaks and troughs in capacity requirements alongside the need to process customer information.

"Higher-value examples are apparent in the utilities industry where power suppliers, for example, could utilise evolved IBN to support their advanced metering infrastructure (AMI)."

4 Who is the supplier of an evolved IBN?

No one type of organisation has the exclusive right, heritage or strong capabilities to provide IBNs. We expect the supply side of evolved IBN to be made up of a blend of network equipment providers, terrestrial and non-terrestrial communication service providers (CSPs), IT providers, systems integrators and consultants. Some will be able to offer the entire evolved IBN package from network to application while others will assemble IBN offerings bringing in partner suppliers.

Given the likely fragmentation of demand in comparison to the relatively homogenous market for traditional networking services, the IBN landscape offers significant opportunities for different types of suppliers. Few enterprises will have the power or level of demand to force a large network equipment provider to develop an intent-specific feature so specialists will be able to jump into the market and produce that feature or develop and provide tools to enable such functions to be created.

Different organisations will either lead innovation, be playing catch-up or trying to recover from failed innovation. These will all seek to collaborate to accelerate their knowledge and capabilities and harness the enormous opportunities. We can easily see models in which a sector specific systems integrator can bring its vertical-specific knowledge to bear to create an evolved IBN in partnership with a CSP and a developer of virtual network functions (VNFs). This multi-party relationship is likely to also involve equipment providers and other consultants to ensure that a tightly-tailored IBN can be configured that delivers a significant uplift in performance and positive outcomes for the customer organisation.

There is significant revenue potential here and we are already seeing large, terrestrial US CSPs exploring how to build specific networks for manufacturing and warehousing organisations. These CSPs are also focusing on automating networks so they can move on from being simply network providers and become providers of services that take an intent and make it a reality. By offering assured, low latency connectivity over a 5G network to a medical monitoring app or a connected vehicle service, CSPs can showcase the value of their infrastructure and, it is anticipated, charge for the value of the service delivered.

This is why IBN has been identified as an important opportunity by CSPs. Some see IBN as an extension of enterprise networking and the private networks market has seen network equipment providers pushing ahead but there is substantial scope for CSPs to also provide IBN systems alongside their network capacity. Division of the market between private networks and macro networks is happening as enterprises acquire their own spectrum to operate private networks but many organisations do not want to become network owners or operators and will look to CSPs' macro networks to provide them with the IBN systems they need.

5 Conclusion

Evolved IBN relies on understanding, customising and applying the advanced technologies that are revolutionising networks. This confluence of innovation is enabled by automation which, in turn, is facilitated by AI. AI inputs provide the means for networks to incorporate the new demands we've described and to handle the complex configuration and adaptation that delivering an intent demands.

Nothing about evolved IBN is easy. But the ability to provide certainty that a set of network attributes will be delivered in support of an application or use case is transformative. There is much to learn and significant difficulties to overcome in handling the sheer scale of evolved IBN adjustments and demands. Nevertheless, the concept stands ready to become reality thanks to the application of AI and deep and machine learning.

We believe the effort will be worth the reward because evolved IBN provides an opportunity for providers of all types to be pioneers of new capabilities. Importantly, these should not be viewed in the same way as just another network service. Evolved IBN instead enables other industries to use suppliers' network capabilities to transform, in some cases radically, their own businesses.

Evolved IBN presents an opportunity for suppliers to monetise their networks, differentiate their offerings and be the enablers of change in an intent-enabled world.

If you would like to discuss how your business can benefit from the emerging innovation in AI and connectivity, or require support in developing high-performance networks, please contact:

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6 Glossary

Advanced metering infrastructure (AMI)
An integrated system of smart meters, communications networks, and data management systems that enable two-way communication between utilities and customers

Artificial intelligence (AI)
The simulation of natural (human) intelligence by machines, including performing tasks such as visual perception, prediction and decision making

Centralised intelligence
Intelligence that exists at a one central location with the network

Communication service providers (CSPs)
Companies that offer telecommunications, media, entertainment, applications, and other information-related services, often over a physical network

Deep learning
A subset of machine learning where algorithms with multiple (deep) artificial neural network layers learn to perform tasks using large amounts of data

Edge devices
A device that provides an entry point into enterprise or service provider core networks

Intent-based networking (IBN)
A method of network administration that uses centralised intelligence to automate network configuration to support a specific set of business requirements

Evolved intent-based networking (IBN)
A method of network administration that uses pervasive intelligence to automate network configuration to support a specific set of business requirements and assure performance

Machine learning
An application of AI that provides systems with the ability to automatically learn and improve from experience without being explicitly programmed

Multi-access edge computing (MEC)
A type of network architecture that provides cloud computing capabilities and an IT service environment at the edge of the network

Network nodes
A connection point in a communications network

Open Ran
Industry-wide Radio Access Network (RAN) interfaces that support interoperability between vendors' equipment

Pervasive intelligence
The deployment of AI into an ecosystem of applications, services devices and system infrastructure instead of at a single location

Quality of experience (QoE)
A measure of a customer's experiences, both positive and negative, with a service

Quality of service (QoS)
A measure of the overall performance of a service, from the network perspective

Secure tunnel
An encrypted link between one network and another

Supervisory control and data acquisition (SCADA)
A computerised system that can gather and process data and apply operational controls remotely

Ultra-reliable low latency communications (URLLC)
A new service category of 5G aimed at mission critical communications, with a target latency of 1 millisecond and requirements for end-to-end security and 99.999 percent reliability

Virtual network functions (VNFs)
Software applications that deliver standard network functions that in previous generations have been provided by dedicated hardware

About Cambridge Consultants

Cambridge Consultants, part of Capgemini Invent, is a world leader in innovation and technology-based consulting, helping ambitious companies achieve the seemingly impossible. From large multinationals to innovative start-ups, our clients trust us to develop breakthrough technologies and solve their most critical, high-risk challenges. With a team of more than 800 staff in Cambridge (UK), Boston, Singapore and Tokyo, we have one of the world's largest independent wireless development teams.

Over the years, we have led the creation of major wireless technologies and developed service platforms that have transformed our clients' businesses. This includes the world's first single-chip Bluetooth radio, radios that manage more than half of the globe's airspace and the most densely packed cellular network in the world, which has revolutionised warehouse automation. We have created breakthroughs that defy convention across diverse markets. These range from telecoms, IoT and satellite, to healthcare, consumer, audio and automotive. This technical expertise and deep market knowledge also provide the commercial insight that helps our clients navigate the emerging technology landscape and offers the intelligence to underpin their most critical strategic decisions.

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