ORACLE Communications

analysys mason

Perspective

Building a best-in-class network for competitive advantage

April 2021

Caroline Chappell

RESEARCH

Contents

List of figures

1. Executive summary

1.1 There is a clear commercial imperative for building a best-in-class network

This paper makes the case for building a best-in-class network based on disaggregated and modular network components that can be procured from the vendor(s) with the best network function(s) to meet a CSP's commercial goals, such as the ability to offer differentiated services and meet new customer requirements. Best-in-class network functions are especially critical in areas of the network where superior performance, security and resiliency are required, such as in the mobile core and the signalling core, and to support policy management. The service-based architecture (SBA) of the 5G network is opening up an exciting new chapter in network disaggregation; it gives CSPs a greater choice of function vendor and means that they do not have to compromise on the capabilities of individual functions as a result of having to buy all functions from a single vendor as part of a monolithic system.

There is a clear imperative for building a best-in-class network. CSPs face unprecedented competition for 5G connectivity from a host of assailants because the software-based nature of the 5G network is making it easier for highly agile competitors from IT backgrounds to target this market. These competitors are attracted to 5G because of its potential to open up lucrative consumer and enterprise markets by supporting use cases that are currently beyond the capabilities of fixed and Wi-Fi-based connectivity. To succeed in these new markets, any service provider will need to assure customers of very high service quality, availability and attractive pricing. A best-in-class network can equip CSPs to win new business that recoups the cost of 5G deployment and extracts full business value from the technology.

CSPs that can master SBA-based integration for best-in-class network functions will be well-prepared for the next wave of network service innovation that will arise from the ability to extend such network functions with new IT service logic to support emerging consumer and enterprise use cases and network slicing. SBA interfaces are based on web technologies, so innovation can take place at a much faster pace than was previously possible when operators had to wait for the development of telecoms-specific, 3GPP interfaces.

1.2 Modern software design is overcoming NFV integration challenges

This paper explains how modern software design, based on cloud-native technologies and agile methodologies, will make it easier for CSPs to select best-in-class network functions. This approach naturally addresses the interoperability and portability issues that made the network function virtualization (NFV) vision of onboarding network functions from multiple vendors to a common cloud infrastructure so difficult.

Physical networks historically locked large blocks of network functions into proprietary boxes, thereby requiring CSPs to procure them from a handful of vendors. This made it more challenging for new vendors with innovative, high-quality solutions in specific areas of the network where incumbent vendors are not always best-in-class to enter the market. NFV attempted to mitigate the risks of vendor lock-in by disaggregating network function software from hardware, and leading operators, such as AT&T, Telefónica, Verizon and Vodafone, embraced the new opportunity to build multi-vendor networks on a common, virtual machine-based 'telco cloud 1.0' infrastructure. However, NFV introduced new complexity as a result of the vertical integration that is needed between network functions, NFV infrastructure and the management and orchestration stack.

The adoption of cloud-native software design and agile methodologies pioneered by IT cloud providers is changing the way in which networking software is built, delivered and operated, and the barriers to network function integration and innovation are falling. A cloud-native approach is leading to a greater choice of network functions, because it makes them easier and faster to develop, and it is providing CSPs with the tools and capabilities to assemble networks from best-in-class network functions based on modern software technologies that are inherently easier to integrate, such as the Kubernetes ecosystem, microservices and containers.

1.3 The 5G core is a good starting point for a best-in-class network

The 5G standalone (SA) core is an excellent starting point for CSPs that want to build a best-in-class network that supports their commercial opportunities in both the consumer and enterprise markets. The 5G SA core's SBA based on modern software principles is designed for disaggregation, and can run flexibly and scalably on cloud infrastructure. CSPs can develop a mobile core that offers the right feature set and price points to accommodate many different use cases, while bearing in mind the considerations outlined in this paper, such as how closely each vendor's roadmap follows technology developments championed by the Cloud Native Computing Foundation, the scalability and portability of the network function and how easily it is deployed in a best-in-class network.

2. Why build a best-in-class network?

2.1 What are the benefits of a best-in-class network?

Components in a best-in-class network are selected because they lead in terms of providing the strongest set of functionalities. The architecture of a best-in-class network is based on the principles of disaggregation and modularity, which reduce vendor-proprietary dependencies between network components and allow them to be implemented independently, regardless of supplier. Best-in-class networks enable CSPs to select the best network function(s) to meet their commercial goals, such as the ability rapidly to offer differentiated services and meet new customer requirements.

The principles of disaggregation and modularity were first championed by the ETSI Network Functions Virtualisation (NFV) initiative almost a decade ago. They underpin the 5G network architecture: the 5G network was envisioned, from the outset, as a set of software components (or applications) that are disaggregated from their run-time environment (cloud-native infrastructure). The 5G SBA embraces the modularity of these software components and actively encourages CSPs to build a cellular network based on best-in-class implementations of each network function at a fine-grained level. The architecture was designed in this way to deliver three key benefits.

- **Vendor choice.** Physical networks, built from connected boxes, historically encouraged the acquisition of network functionality from a single vendor. The hardware itself was expensive, proprietary and typically under-utilized. One Tier-1 CSP reported using only 35% of the capacity of the servers supporting its legacy physical IMS, which encouraged it to buy all of its IMS functions from a single vendor to gain at least some hardware economies of scale. Few vendors practised modularity in the development of software for physical appliances: they instead built network functions with monolithic architecture in the expectation that CSPs would buy an appliance based on the number of features it supported, regardless of the quality of the implementation of those features. Inevitably, vendors had their strengths and weaknesses across a suite of network functionality because it is hard for any one vendor to be best-in-class across all functional domains. Disaggregation in the 5G network is opening up an exciting new chapter in which CSPs have more vendor choice when procuring functions for the 5G RAN and core. This is an important benefit because choice means that CSPs no longer have to compromise on the capabilities of individual functions as a result of having to buy all functions from a single vendor as part of a monolithic system.

- **Access to innovation.** CSPs assumed, in the early days of NFV, that the disaggregation of network software from proprietary hardware would reduce capex because they believed that the cost of a network function lay in hardware rather than software. However, any capex savings were quickly eclipsed by the cost of managing and orchestrating a virtualized, multi-vendor environment. CSPs have since realized that the greater benefit of moving network functions to the cloud comes from the ability to both access a more diverse supplier ecosystem that uses cloud technologies and bring innovation to market more quickly (thereby increasing competition and driving down cost). For years, networks have been undifferentiated; every CSP has used the same handful of suppliers, who, in turn, are confined to providing more or less the same set of services. SBA-based disaggregation enables CSPs to differentiate their networks and services in two ways. First, through the adoption of innovative components from specialist, agile vendors. CSPs have the opportunity to monetize such best-in-class innovations ahead of their rivals that are dependent on the roadmaps and timescales of monolithic network function vendors. The second source of differentiation results from SBA's support for APIs between network functions that are based on web services technologies (HTTP/2, REST and JSON) rather than on telecoms-specific protocols. This enables CSPs to provide external applications with access to data from network functions (such as policy control and network data and analytics) in innovative ways. For example, APIs could enable an industrial automation application to gain direct access to quality-of-service parameters in the 5G network, or an automated vehicle to trigger the creation of a new user plane instance in a closer location as it moves, or a service assurance application to tap into network analytics.

- **Alignment with business goals.** Procuring best-in-class components from a broad set of vendors enables CSPs to assemble the networks that they require at an optimized cost to meet the needs of their businesses. For example, a CSP may want to provide a 5G network with market-leading security and resilience, or with very high levels of automation or easy-to-use, open APIs to support customer self-service, or a combination of all of these properties. The CSP will want to select best-in-class network functions to fulfil these requirements, especially in areas that critically affect both the operational excellence of the network, such as signalling and routing and analytics, and the speed at which they can implement new business models, such as policy control.

2.2 Why build a best-in-class network today?

Leading operators such as AT&T, Etisalat, NTT, Telefónica, Telenor and Verizon have been investing in multi-vendor, best-in-class NFV networks for almost a decade and are strengthening their commitment to this approach as they build out their 5G networks. Their pioneering stance is becoming the 'new normal' for the telecoms industry in a 5G world and it will be critical to business survival. Fortunately, the commercial imperative to have a best-in-class 5G network is easier to address than it would have been in the past due to advances in modern software design. CSPs have an opportunity and the tools to build a differentiated 5G network today, at a time when their need for a such a network has never been greater.

Competition to provide 5G connectivity will be fierce because of its potential to open up lucrative consumer and enterprise markets by supporting use cases that are beyond the current capabilities of fixed and Wi-Fi-based connectivity. CSPs are facing unprecedented competition in their fixed and mobile connectivity businesses from a host of assailants, including public cloud providers (PCPs), data center owners and other neutral hosts, newentrant fixed and mobile virtual network operators and systems integrators. Access to new unlicensed spectrum and 5G spectrum that is assigned for industrial use is driving a market for private 5G networks for enterprise customers. New entrants' agility and cloud-native software skills mean that they can typically price private 5G network solutions more attractively than traditional CSPs can.

To compete successfully in new 5G markets, CSPs will need to differentiate themselves to customers by providing very high levels of service quality, security and resiliency and attractive pricing. 'Good enough' networks can prosper in markets with low levels of competition, weak interest in industrial automation and a lack of national ambition, but the majority of CSPs will need 5G networks that are as competitive as possible. A best-in-class network can equip CSPs to win new business that recoups the cost of 5G deployment and extracts full business value from the technology.

Disaggregation and modularity are supported by a new breed of cloud-native tools and technologies and IT best practice approaches to software delivery and integration. The telecoms industry is specifying network standards based on these modern IT practices and 5G networks are a catalyst for their introduction. Vendors are developing 5G network functions as cloud-native software components: cloud-native software is specifically designed for operational automation, agile delivery and API-based integration. The adoption of such IT approaches makes the building of a 5G network from best-in-class network functions feasible today without the need for large custom integration projects, as we will explore in the next section.

CSPs that can master the SBA framework that makes it easier to select best-in-class network functions will also be well-prepared for the next wave of innovation in network services. Such innovation will arise from the ability to add new web service functions to support emerging services such as IoT in differentiated ways, for example, through customized network slices. SBA's HTTP/REST-based web service interfaces support both third-party function integration and web service-based innovation at a much faster pace than was possible using the historic approach in which CSPs had to wait for the development of 3GPP interfaces.

3. Building a best-in-class network is becoming easier

3.1 Traditional software design created integration and innovation challenges

CSPs have pursued their ambitions to build best-in-class networks for many years. As long as network functions remained in boxes, their protocol-based interfaces could be defined by standards organisations, thereby ensuring a reasonable level of vendor interoperability, as we discuss below. However, as soon as network functionality migrated out of proprietary boxes and into software, CSPs started to face heavy, non-functional integration challenges that translated into high cost and time-to-market risks. Analysys Mason's research shows that almost 75% of NFV implementations today are still 'virtual appliances' where the virtualization stack, network functions and orchestration all come from a single vendor because of the difficulties of integrating components from multiple vendors. Forward-thinking CSPs that are associated with high-profile 5G software-driven initiatives such as Open RAN (ORAN) (examples include BT, Dish, T-Mobile and Vodafone) understand that single-vendor approaches create a high degree of industry dependence on a handful of vendors, which is itself a risk that they are keen to mitigate. They are also aware that integration risks have raised the barriers to entry for new vendors that have innovative, high-quality solutions in specific areas of the network where incumbent vendors are not always best-in-class.

3GPP had gone some way to addressing integration challenges in the physical mobile network by defining the interfaces between proprietary appliances. One vendor's appliance could interoperate with another's, provided that vendors conformed to 3GPP interfaces. However, vendors faced a far larger interoperability challenge when they started to pull software out of appliances: the daunting task of integrating a complex and non-agile software system into a new, vertical and agile technology stack, consisting of the vendor-neutral, virtualized infrastructure the software had to run on, that infrastructure's management and orchestration environment and, potentially, new or established operational support systems (OSS).

The traditional, monolithic way of building telecoms software, in which coded functions are tightly coupled within large and complex software systems, has been a key barrier to integration in the NFV environment. Monolithic software is built using a waterfall model of development that gathers all user requirements at the beginning of the development cycle and implements them as 'black box' functionalities with project-specific system attributes, little or no reuse of common software functions and complex interdependencies between lines of code. This approach has two important disadvantages.

- Monolithic software systems can be challenging to integrate due to the proprietary, tightly coupled nature of their code. Even when conformance with 3GPP interfaces eases integration at the protocol level, each monolithic system is likely to duplicate non-functional software features that, for example, ensure its security and compliance, monitor its performance and manage its data. Each system implements these features in different ways, which can be inefficient and expensive to manage and causes integration challenges in an NFV stack.

- Network functions developed as monolithic systems are not agile. Introducing new features into monolithic software systems is a slow and difficult process, so they cannot respond quickly to innovation and cannot easily be adapted to interoperate with others.

The complexity of monolithic telecoms software systems was highlighted when CSPs migrated onto virtualized infrastructure. The monolithic software package (a virtualized network function (VNF)) needed to be managed not only as a software component with a software lifecycle, but also as a network function with a separate set of configuration and management processes. The integration of many monolithic VNFs with a common, multi-vendor NFV infrastructure remains a challenge after almost a decade's worth of NFV interface development. It is also difficult to manage VNFs from different vendors in the same way. CSPs that have tried this route have not yet fully realised the benefits of virtualization; some have dismissed it as an option for being too hard. CSPs have instead typically adopted monolithic 'virtual appliances' where single-vendor VNFs run on dedicated hardware managed in traditional silos. This approach mirrors the traditional, physical network and does not offer the agility and speed of innovation advantages that were an early promise of NFV.

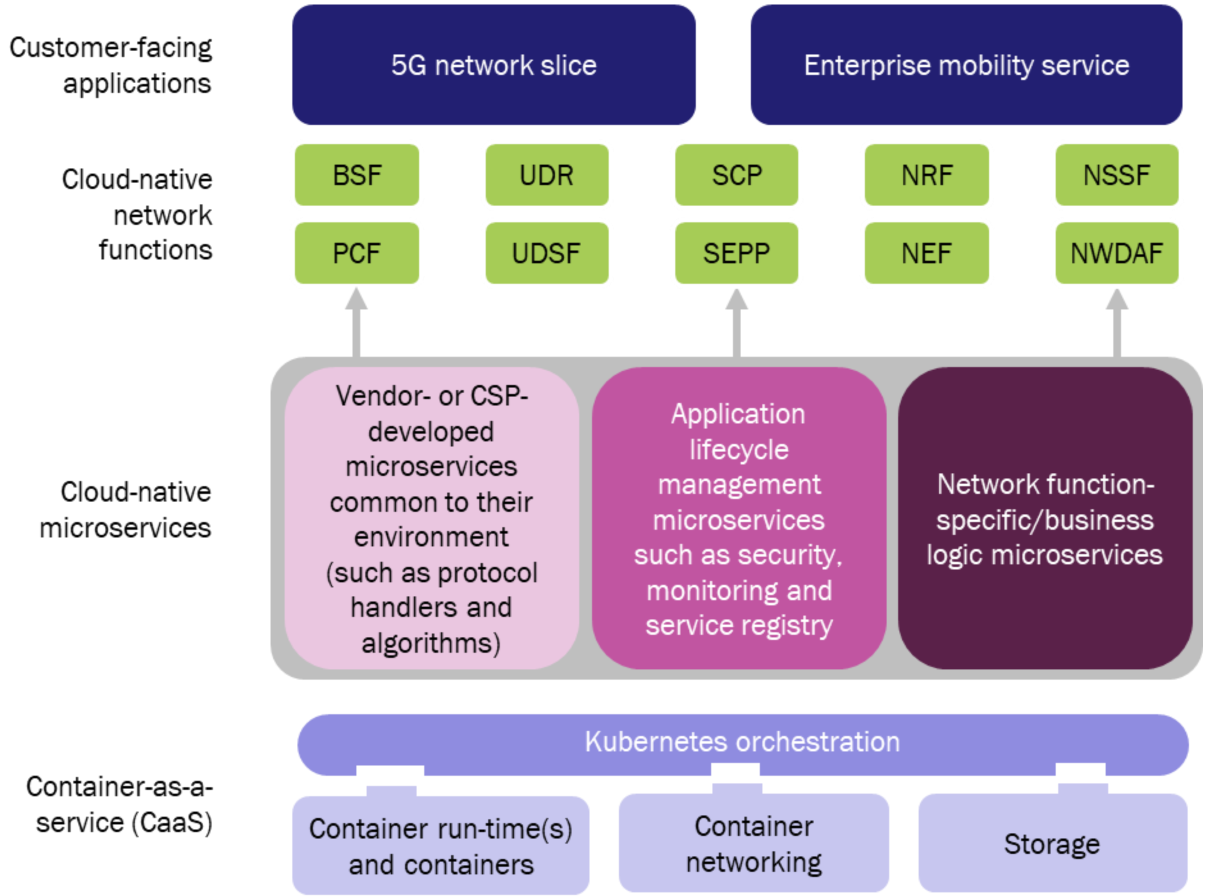
3.2 Agile approaches are revolutionizing software development

The use of the cloud as a run-time environment for modern applications has encouraged a revolution in software design based on agile development methodologies. Agile development is all about the incremental development of small, loosely coupled software components (known as microservices) that can be developed quickly, that run efficiently in the cloud and that are inherently easy to integrate with one another.

Agile methodologies also support rapid innovation due to the API-enabled modularity of development and microservices reuse. System attributes that all components need to use (known as non-functional requirements) are realized as separate, common microservices with open APIs so that any new microservice can call them and developers do not have to reinvent areas of functionality every time they build a new software system. Many of these common components are being developed by open-source initiatives under the auspices of the Cloud

Native Computing Foundation (CNCF), which oversees the components' development roadmap and suitability for commercial adoption. Customer-facing applications and network functions have become 'composable' software systems assembled from best-of-breed microservices, including vendor-developed microservices and best practice open-source microservices, as Figure 3.1 illustrates.

Figure 3.1: Microservices-based composition of cloud-native network functions and applications



Source: Analysys Mason, 2021

The barriers to integration and innovation are falling as the network industry adopts cloud-native software design and changes the way in which networking software has traditionally been built, delivered and operated. A cloud-native approach is leading to a greater choice of network functions because composable systems are easier and faster to develop. Indeed, the explosion in the number of 5G cores now available on the market attests to the power of cloud-native design when it is applied to networking software. There is also greater scope for network function developers (that are often working in partnership with CSPs) to innovate within their solutions and CSPs have more opportunities to assemble networks from best-in-class network functions, instead of having to implement a monolithic system.

3.3 Best-in-class network functions are taking advantage of modern software design

The following three aspects of modern software design are helping to enable best-in-class networks by supporting the integration, common management and portability of cloud-native network functions, such as the 5G core.

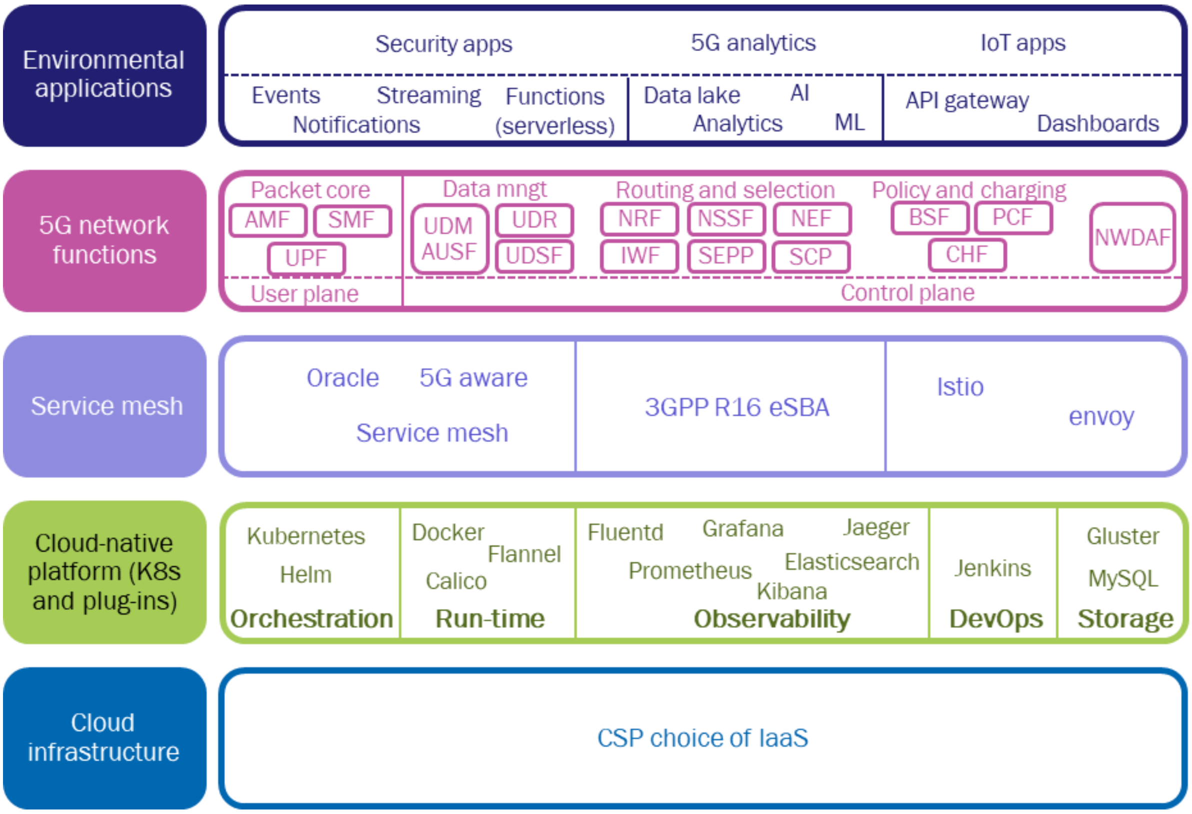
- **Integration.** Cloud-native technologies include microservices and containers, which have been conceived as independent units that work together to provide system functionality. The ability for such technologies to integrate with each other is therefore an inherent aspect of their design. Containers are units of software with standardized formats (such as Docker) that support disaggregation by isolating applications from cloud run-time environments, thereby providing a high level of portability across different cloud stacks. Microservices, which implement application functions, run in containers and have properties that make them easy to individually modify, upgrade and add into an environment without a large integration overhead. These properties include support for loose-coupling, independent scaling and release cycles, live updates and integration with a service mesh. A service mesh is a communication fabric that connects all microservices instances participating in the same application. Open APIs are fundamental to the implementation of cloud-native technologies, and are also critical to the ease of software-based integration.

- **Common operations.** Microservices and containers are lifecycle-managed using a common orchestration platform (Kubernetes) and a range of open-source tools that plug into the Kubernetes platform. Work is underway within the ETSI NFV Management and Orchestration organization to ensure that there are standardized interfaces between the Kubernetes-based container management platform and other MANO components, such as the NFV Orchestrator (NFVO). Such integration will result in a single orchestration stack that enables all cloud-native network functions, and their constituent microservices, to be managed in a consistent, common way. This is a big step forward from the early days of NFV when each VNF required its own lifecycle manager, and no two VNF managers implemented exactly the same set of operations. It is also very different from the idiosyncratic and siloed management environments for each monolithic, physical network function. Reconciling management capabilities across systems is often a major integration challenge that modern software design helps to minimize.

- **Portability.** Cloud-native software components are insulated from the underlying cloud run-time environment by a Kubernetes-based container management platform (container-as-a-service (CaaS)). Widespread cloud support for CaaS means that cloud-native components (such as 5G network functions) can be delivered on different cloud stacks without the need for heavy integration work. Kubernetes does more than simply orchestrate cloud infrastructure (containers). Application lifecycle management utilities that address non-functional requirements (such as monitoring, logging, auditing, data management, security and messaging) can also plug into, and be orchestrated by, Kubernetes. Many of these plug-ins are open-source and can be curated as a platform-as-a-service (PaaS) so that functional microservices (for example, those that deliver specific network functions) can call on them without developers having to redevelop or select and implement supporting capabilities. The market is converging on a common set of such open-source plug-ins, which also helps to make functional software portable across different cloud-based platforms.

Best-in-class functions are typically developed using leading-edge, cloud-native software design since their vendors are incentivized to make them easy to integrate. Figure 3.2 depicts a 5G core built from best-in-class network functions using a cloud-native software design and platform.

Figure 3.2: 5G core implementation using modern software design



Source: Oracle, 2021

4. What to look out for in a best-in-class approach

The 5G SA core is an excellent starting point for CSPs that want to build a best-in-class network that supports their commercial opportunities in both consumer and enterprise markets. The 5G SA core has an SBA that is based on modern software principles and is designed for multiple levels of disaggregation. For example, the 5G SA core can be disaggregated from the RAN in order to run flexibly and scalably on cloud infrastructure, and CSPs can construct a mobile core that offers the right feature set and price points to accommodate many different use cases. This is particularly important in an enterprise context where the 5G core will provide critical support to new industrial transformation use cases in private network deployments. It is also a key enabler of 5G network slicing. A further design feature of the 5G core that enables best-in-class implementation is the disaggregation of its control and user planes so that they can scale separately to reflect their different focus on signalling and traffic flows. This allows CSPs both to choose the best-performing 5G core control plane functions (such as policy control, signalling and routing and analytics) separately from user plane functions and to deploy 5G core functions flexibly across a distributed network cloud infrastructure in order to support customer latency, data privacy and capacity requirements.

CSPs that are planning to procure a best-in-class 5G SA core should consider the following issues to ensure that the network functions they select integrate well with one another, can easily be orchestrated and maintained and are portable.

- **Cloud-native credentials**. Does the vendor have strong cloud-native credentials and experience with cloud-native technologies? Is it a member of the CNCF and does it have extensive in-house cloud-native development skills? How closely does the network function vendor's roadmap follow the CNCF's definition of a cloud-native application (for example, does it use technologies such as microservices, containers, service meshes and declarative, open APIs and does it ensure that its microservices are loosely coupled and stateless)?

- **Support for automation and CI/CD**. Is the network function resilient, manageable and observable, with a high level of lifecycle management automation? Can it be changed and upgraded using continuous testing and deployment automation using a CI/CT/CD pipeline?

- **Scalability.** How scalable is the network function's feature set? Does it scale down for enterprise deployments (for example, to support a dedicated, private 5G network) as well as up for high-scale mobile broadband roll-outs?

- **Deployment options.** What deployment options does the network function vendor support and how well can the network function integrate into different deployment scenarios? For example, can the network function be deployed onto different cloud platforms using different IaaS/CaaS options? Can it integrate with CSP-specified PaaS? Can it be offered by the vendor in a cloud-native software-as-a-service model?

- **Ease of customisation.** How easy is it for the CSP to co-create microservices? How easy is it for the CSP to integrate new services with the network function's cloud-native platform to create customised, application logic that it can use to differentiate its service offer?

- **Cloud-native management.** How cloud-natively can the network function be managed? Can it easily be onboarded into the CSP's management and orchestration stack? Does it support cloud-native templates and lifecycle management approaches?

- **Proof of performance.** Is there evidence that the network function has been deployed in a best-in-class network? Is there an ecosystem of third-party functions and platform components with which its integration is already proven?

5. Conclusion

Competition in the telecoms sectors in most countries is already fierce and is getting stronger as a result of 5G deployments. The 5G network has been conceived as a set of software-only network functions that can run on cloud infrastructure, thereby opening the door to new market entrants that have the right skills to build and operate such a cloud-based network. 5G's SBA is based on modern software design principles, including open APIs that support the disaggregation of monolithic network functions and the ability to introduce software-based components from best-in-class vendors. The winners in the increasingly contested 5G market will be those companies that select and implement network functions with features that are closely aligned with their business goals and which deliver differentiated performance and/or service capabilities.

Multi-vendor network function interoperability was complex in the early days of NFV, but is now becoming viable thanks to cloud-native approaches that address application integration, portability and automation. CSPs have a solid opportunity to build a 5G network composed of best-in-class functions, regardless of vendor. A cloud-native, disaggregated network holds the promise of faster innovation, both within network functions themselves because best-of-breed vendors can typically implement new features faster than traditional suppliers of monolithic functions, and through the ability to extend functions with IT service logic through open APIs. CSPs that are able to take advantage of such innovation will be in a stronger position to generate new revenue, especially in the enterprise market, a key focus for 5G.

6. About the author

Caroline Chappell (Research Director) heads Analysys Mason's Cloud and Platform Services practice. Her research focuses on service provider adoption of cloud to deliver business services, support digital transformation and re-architect fixed and mobile networks for the 5G era. She is a leading exponent of the edge computing market and its impact on service provider network deployments and new revenue opportunities. She monitors public cloud provider strategies for the telecoms industry and investigates how key cloud platform services can enhance service provider value. Caroline is a leading authority on the application of cloud-native technologies to the network and helps telecoms customers to devise strategies that exploit the powerful capabilities of cloud while mitigating its disruptive effects.

Prior to joining Analysys Mason, Caroline was Practice Leader, Cloud and NFV, at Heavy Reading. She has over 25 years' experience as a telecoms software analyst and consultant working for research companies including Current Analysis and Ovum. Her areas of coverage spanned cloud services, digital service development and delivery, B/OSS, customer experience management and analytics, Internet and cloud security, professional/managed services and service provider wholesale strategies in such areas as IP/Ethernet, enterprise cloud solutions and fixed and mobile wholesale access. Caroline started her career as a software programmer at what is now BAE Systems. This has given her a lifelong interest in software architecture and engineering approaches, most recently including lean/agile development and DevOps, microservices architecture and model-driven, intelligent software automation.

This perspective was commissioned by Oracle. Analysys Mason does not endorse any of the vendor's products or services.