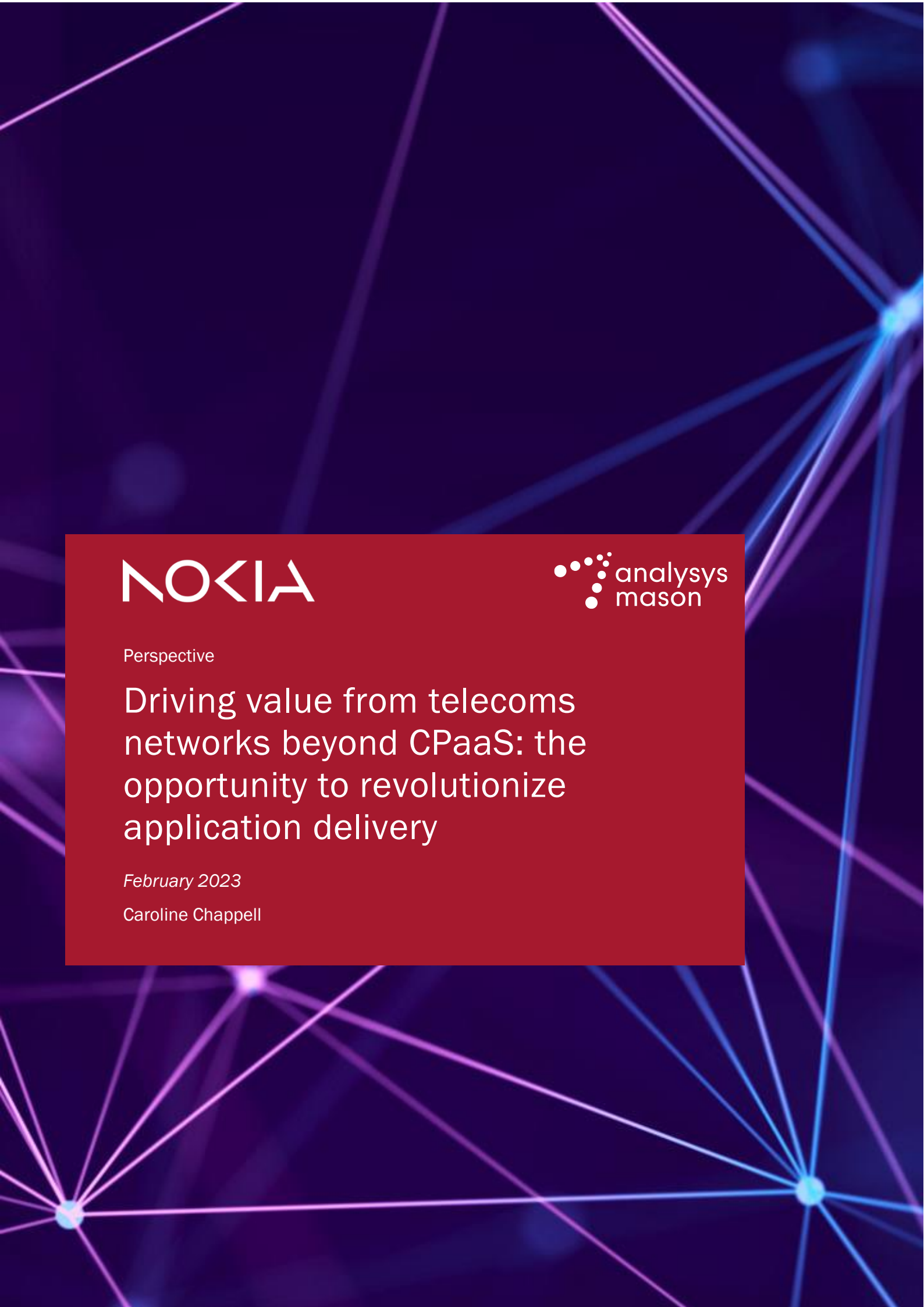

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Perspective

Driving value from telecoms networks beyond CPaaS: the opportunity to revolutionize application delivery

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Contents

List of figures

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1. Executive summary

1.1 Unleashing 5G network features will create new revenue opportunities for an ecosystem of CSPs, enterprises and developers

Communications service providers (CSPs) invested USD103 billion in building 5G networks in 2022 and are expected to spend a further USD129 billion in 2023. The 5G networks they are rolling out contain many new features that are designed to support the needs of Industry 4.0 use cases, such as drone-based remote inspection, public safety, automated guided terrestrial vehicles, digital twin-driven supply chains, reconfigurable manufacturing systems and mixed reality-based maintenance. These use cases will transform operational processes across industry sectors so that they deliver new levels of efficiency, customer experience and sustainability but the processes will not function without secure, highly available, resilient and low-latency connectivity to support them.

Network features need to be an integral part of Industry 4.0 application software so that developers can match specific properties of the network, such as quality of service and hyper-accurate positioning, to the specific needs of their use cases. This represents a departure from the way that developers have built operational applications in the past, where they treat networks as 'dumb' connectivity despite the significant amount of intelligence that networks actually contain. Since 5G networks are the first telecoms networks to be built as cloud-native, software-defined infrastructure that can run in the cloud in a similar way to emerging cloud-native operational technology (OT) applications, 5G network features can be programmed into OT application pipelines and can interact directly with OT applications through application programming interfaces (APIs). When developers can call network features through APIs and combine them with application logic, they can address new Industry 4.0 cases that have not been previously achievable, boosting innovation and creating new value for enterprise customers.

Such is the promise of a new network-enabled ecosystem that encompasses network owners (CSPs) developers and enterprises. All the stakeholders in this ecosystem want to generate new revenue from Industry 4.0: CSPs by giving developers access to the network properties that they are investing in so heavily; developers from the new application experience that they can deliver as a result of this access; and enterprises from the new products and services that the applications will support. However, the birth of such an ecosystem (Figure 1.1) faces two major challenges.

- Developers are not network specialists so they need a familiar way of accessing and incorporating a wide range of network capabilities into their applications, through simplified APIs, software development toolkits (SDKs) and code development support services. If the ecosystem is to attract a critical mass of developers, it must also provide developers with a common set of network APIs that work across multiple CSP networks. Developers expect to develop once and have their applications work across any network. If an individual CSP provides network APIs in a 'walled garden' model that does not follow industry standards, it will limit the number of developers prepared to use its APIs.

- CSPs need a return on their substantial investment in 5G and the valuable properties they are building into their cloud-native networks. It is expensive to build feature-rich 5G and 5G advanced networks and CSPs want to maximise their revenue gain from the increasing number of features that their networks provide. CSPs need a way of providing developers with the common set of APIs without having the value of those APIs stripped away from them by a third-party aggregator.

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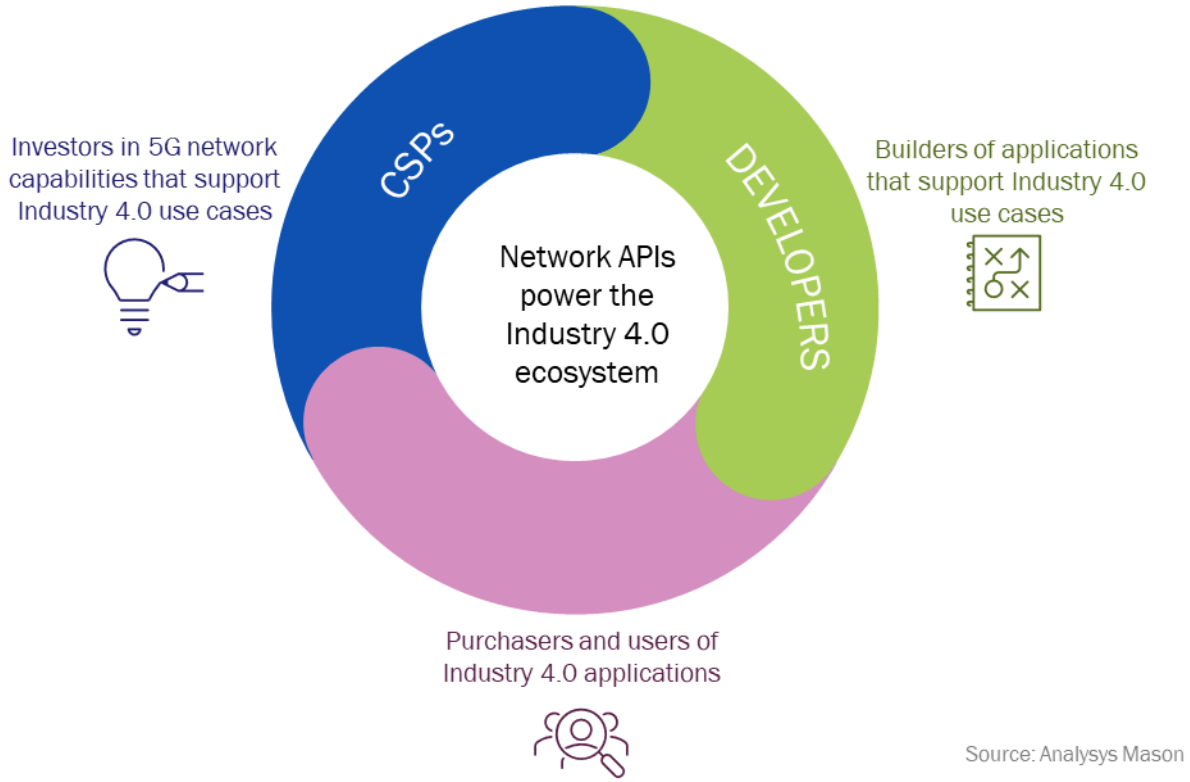
Figure 1.1: Network-enabled ecosystem driving Industry 4.0 use cases



1.2 The emerging Industry 4.0 ecosystem needs a network platform as a service

The solution to the challenges outlined above is a network platform as a service (NPaaS), a platform that is both a successor to the communications platforms as a service (CPaaS) that already exist in the market, and a major upgrade to the CPaaS scope and business model.

The CSP-developer-enterprise ecosystem receives limited benefits from CPaaS today. CPaaS is a thriving market that has been built by new platform providers that disintermediate CSPs from developers and enterprise customers. This restricts CSPs' revenue-earning potential from the voice, video and messaging services that underpin CPaaS provider APIs. CPaaS also limits what developers can do with the network: CPaaS provide developers with a narrow set of communication services APIs whereas Industry 4.0 developers will need access to a much broader set of network capabilities.

Nevertheless, CPaaS points the way to the right platform architecture for putting network APIs into the hands of developers. A CPaaS is fed by communication services from multiple CSPs, over which it layers a common set of developer-friendly APIs as an abstraction that shields developers from the complexity of individual CSPs' implementations. The same approach would work well for a NPaaS with two distinctions.

- **Breadth of scope:** The NPaaS would provide a far more extensive set of network-based capabilities enabled through the simplification of underlying network APIs relating to quality of service, mobility, security and many other features in addition to the communications services exposed through a CPaaS.

- **New business model:** The NPaaS should be delivered as an enabling platform that aggregates access to multiple CSPs for developers but allows CSPs themselves to take the platform and its APIs directly to enterprise customers without disintermediation.

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The NPaaS will allow CSPs to achieve a key objective as they deploy their 5G networks, which is to monetize the rich, software-based functionality that is designed into the world's first cloud-native network. CSPs that are ready to expose their 5G assets through such a platform will help to change Industry 4.0 developers' perception that the network is a dumb pipe that they can safely ignore. CSPs can collaborate with developers to unleash the potential of network-critical operational applications and drive new value from their networks as a result.

1.3 The NPaaS architecture is critical to achieving ecosystem goals

This report enumerates the key requirements for an NPaaS platform. Unlike CPaaS platforms, many of which are now over a decade old, an NPaaS platform needs to be built using a cloud-native, extensible architecture that can support network capabilities that are available in 5G networks today and which will continue to be rolled out towards 6G networks in future. It should provide intent-based interfaces and intelligent orchestration to simplify developer access to complex network capabilities that may span network domains and functions. The platform should also be able to execute its broad range of APIs in a timely manner and at high scale regardless of the number and complexity of the concurrent transactions it is asked to handle.

The NPaaS platform needs to offer value for developers, CSPs and enterprises as Industry 4.0 transformation unfolds.

2. A good opportunity to add new value to application delivery in a network-critical world

2.1 Developers are about to gain unprecedented access to network smarts, triggering the next wave of innovation

The next wave of application innovation will be driven by access to network functionality that is currently the province of networking specialists and which has so far been unavailable to a broad community of application developers.

Modern applications are built using a service-based architecture and are increasingly assembled from independent services that run in different locations. Developers need seamlessly to connect to these distributed service locations but today they treat the networks that supply critical connectivity as dumb pipes. This is because the full range of smart features that exist in the network has never before been made available to developers in a simplified way that they can consume through familiar tools and processes.

Access to new network features will be particularly valuable to the class of Industry 4.0 developers that are looking at ways of bringing OT to the cloud. Such developers will want the highest level of control over the connectivity that enables their OT applications to reach and consume resources from the cloud, ensuring their applications' security, resilience and performance.

The market is on the cusp of a revolution that exposes network capabilities to developers of industrial and enterprise systems so that they can build network-critical applications that meet new business needs and drive new economic value. Analysys Mason has estimated that the opportunity for new enterprise use cases that can

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benefit from the capabilities being designed into 5G and 5G advanced networks will be worth nearly USD300 billion.[1]

2.2 Immersive industrial and consumer applications will demand a new approach to connectivity that is developer-controlled

Developers that can integrate network functionality into their application business logic will accelerate a market trend that is already underway. Companies are seeking to make their business assets available to a broad range of users, both internal and external, in a software as a service (SaaS) model, through application programming interfaces (APIs) that can be called on-demand. They want to consume third party assets in the same way. Adapting to a SaaS-based software development approach is a key element of companies' digital transformation initiatives across the globe as organizations seek to improve the agility and efficiency of their processes and to monetize internal capabilities. The higher the number of companies that can provide and consume SaaS services, the richer the resulting application ecosystem. The more participants in an ecosystem, the greater the scope they have to drive innovation from novel ways of assembling each others' services and the more value the ecosystem creates for all its stakeholders.

However, all ecosystem participants need confidence in the availability, resilience, performance and unbreakable security of the networks that connect their services. The SaaS-based ecosystems that will support Industry 4.0 applications of the future, such as drone-based remote inspection, public safety, automated guided terrestrial vehicles, digital twin-driven supply chains, reconfigurable manufacturing systems, mixed reality experiences, virtual worlds, remote healthcare systems and many others, will be highly complex. Such ecosystems will demand that participating services are connected with specific performance, throughput and security features that are an integral part of the applications that deliver the services. They will want to bond those network features directly into their applications through APIs rather than depend on infrastructure that is outside their applications' control.

Developers of enterprise and industrial applications will be building for new, computer-generated industrial metaverses that will consist of millions of microservices and applications from multiple providers (Figure 2.1). The goal of such virtual environments is to drive elevated levels of business efficiency, customer engagement, sustainability and safety as they optimise the visualisation, building, operation and management of real-world objects and processes. A plethora of new technologies is emerging to take the data-driven simulacra of physical industrial environments, such as robotic production lines, logistics hubs, drone superhighways, smart cities and virtual workplaces to a new level of virtual reality, including AI/ML, haptics, motion tracking and volumetric video streaming, photorealistic rendering, hyper-accurate positioning and virtual reality.

[1] For more information, see Analysys Mason's *The 5G network: an experiment with a USD300 billion prize*.

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Figure 2.1: In an industrial virtual world, every physical object or thing will have a computer-generated, connected twin

Source: Analysys Mason

These new technologies will place unprecedented quality of experience (QoE) demands on networks. They will also challenge current developer preferences to depend heavily on virtual world engines that run on local devices today because developers do not factor in and cannot control the network. If developers continue to 'work around' the network, they will reach the limits of the kinds of industrial and enterprise virtual world applications they can build. This is firstly because local processing is ultimately constrained, for example, by battery power in mobile phones or heat risk in VR headsets, while the new technologies that will underpin new application ecosystems are hungry for processing power. Second, local processing will not support shared-state interactions between users of industrial/enterprise virtual world applications unpredictably at scale. This capability will be necessary to simulate real-world experience in different types of virtual world.

However, if developers can directly control how the network supports future industry and enterprise applications by harnessing the processing power of the cloud and delivering the QoE each end-user needs, developers will no longer be constrained by application architecture that assumes that the network is a dumb pipe. Developers will be able to take full advantage of emerging technologies and create network-enabled business experiences that have never been possible before. Their applications will increasingly run across distributed clouds in a SaaS model and will therefore need to exploit specific properties of the network to execute in a timely manner.

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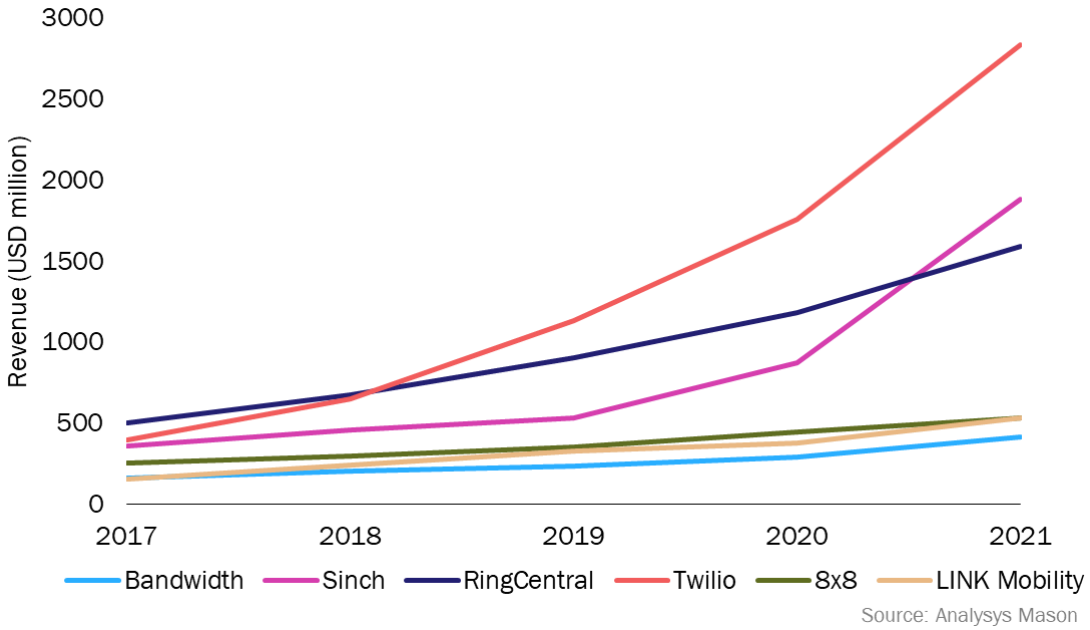
3. The potential for network APIs extends beyond the limits of CPaaS

3.1 CPaaS set an early precedent for developer access to network services but provides limited benefits to developers and CSPs

Developers need the keys to the powerful and wide-ranging collection of network capabilities that CSPs are implementing in, for example, their 5G networks, but which today can only be accessed by network specialists. This means giving developers a platform where they can easily discover and securely use a compact yet powerful set of APIs, SDKs and code developer support services to abstract and aggregate complex network functionality in a simple and highly consumable way across multiple CSP networks. The platform should also provide developers with a straightforward and transparent settlement mechanism.

Such a platform model has already been proven with a very limited set of communications APIs that provide developers with access to voice, text (SMS and MMS), video, email and authentication services that are embedded into CSPs' networks. CSPs had tried to address the CPaaS market opportunity themselves but their efforts failed for two reasons. First, the fragmented geographical nature of CSP solutions did not appeal to developers who want to call a single API call that works across multiple CSP networks. Second, CSPs were not sufficiently supportive of industry-wide standardization efforts at the time, which were in any case too low-level and technical to attract developers. CSPs ceded the CPaaS market to start-ups, the first of which was Twilio in 2008. Now Twilio leads a pack of more than 20 companies that have set up CPaaS that provide developers with a common set of APIs for CSPs' communications services. CPaaS is a thriving business for the many platform providers that have built this market (Figure 3.1).

Figure 3.1: Revenue by CPaaS provider, 2017–2021



Source: Analysys Mason

CPaaS providers offer APIs to at least two communication services, for example, voice and video or voice and messaging. The fastest-growing CPaaS providers, such as Twilio and Sinch, provide developers with access to

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multiple APIs for voice, messaging, video, email and SIP trunking. CPaaS is a multi-billion dollar market with the leaders benefiting from healthy revenue and profits: Twilio reported revenue of USD2.8 billion in 2021 when Sinch's was USD1.8 billion. Developers are clearly interested in CPaaS APIs, but CPaaS does not translate into a significant revenue opportunity for CSPs and CPaaS providers actively disintermediate CSP relationships with enterprise customers and developers.

3.2 The NPaaS offers more value to the application ecosystem than is available through CPaaS

CPaaS points the way to the right platform architecture for putting network APIs into the hands of developers. Its platforms are fed by network capabilities from multiple CSPs, over which it layers a common set of developer-friendly APIs as an abstraction that shields developers from the complexity of network APIs and also from the different ways in which the capabilities are implemented in different networks.

Technically, a NPaaS would work in the same way as CPaaS but with a much more extensive set of network-based capabilities enabled through the simplification of underlying network APIs in addition to those provided by a CPaaS. The broader set of network capabilities will provide new value to developers by revolutionizing the way they can deliver applications, for example, by:

- telling an application where a device is to a very high level of accuracy
- triggering a response when a device enters or leaves an area
- using the network's ability to sense objects and map surroundings, for example to enrich augmented reality (AR) applications
- controlling the network quality of service that an application receives beyond best-effort
- enabling the creation of customized connectivity with policies and features that differentiate the way the application behaves
- providing security capabilities that are customized for the application
- enabling the application to control and manage its communications with IoT devices on a massive scale
- taking advantage of network performance data to control the placement of applications across distributed cloud locations for optimal latency
- providing access to the network's charging capabilities so that the application can monetize end-user data consumption.

An NPaaS will also allow CSPs to achieve a key objective as they deploy their 5G networks, which is to monetize the rich, software-based functionality that is designed into the world's first cloud-native network. CSPs that are ready to expose their 5G assets through such a SaaS-based aggregation platform will help to change developers' perception that the network is a dumb pipe that they can safely ignore. CSPs can collaborate with developers to unleash the potential of network-critical modern applications and drive new value from their networks as a result.

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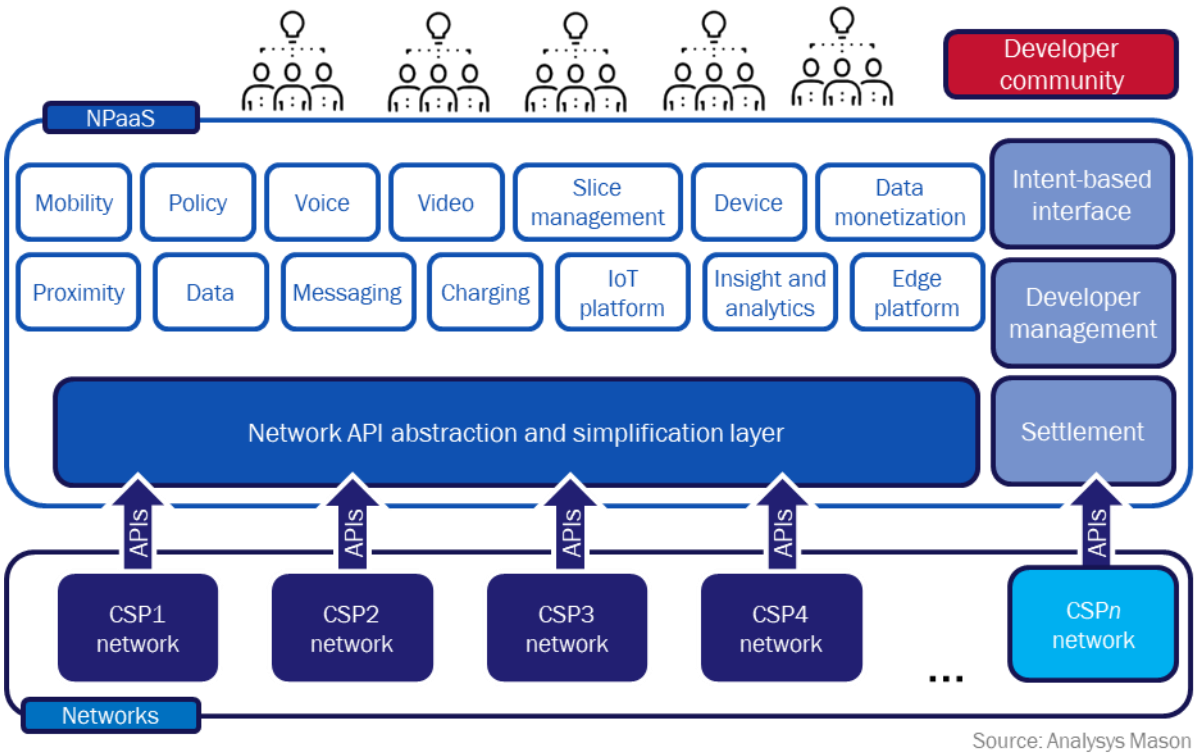
Figure 3.2: An example NPaaS platform architecture



Source: Analysys Mason

3.3 The application ecosystem will benefit from a radically different way of deploying NPaaS

CSPs have lost out in the CPaaS market so they need to ensure they do not miss the far more extensive and valuable opportunity for NPaaS. CSPs need to take a radically different approach to safeguarding NPaaS revenue while ensuring that developers enjoy the full benefits of a CSP-neutral platform.

Such a network platform must offer developers common, simplified access to network capabilities, regardless of how an individual CSP has implemented them, so it should ideally be provided by a third-party platform provider that can aggregate access to multiple CSPs. However, in a new NPaaS ecosystem, the platform provider should play an enabling role, allowing CSPs to be the direct channel to market for the platform's common set of APIs. As an enabler of the NPaaS ecosystem, the NPaaS provider may help CSPs to build a developer community but it should not disintermediate CSPs in the way that CPaaS providers currently do. This will incentivize CSPs to join the platform because they will directly benefit from its revenue. The larger the number of CSPs present on the platform, the more developers will benefit from what can become the broadest possible set of network capabilities consumable through CSPs everywhere.

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4. Key success factors for the NPaaS

4.1 The deployment of cloud-native 5G networks is a critical enabler of the NPaaS opportunity

Multiple technology developments are converging to make the NPaaS opportunity possible. The 5G network is the first telecoms network that can run in the cloud in a similar way to emerging Industry 4.0 cloud-native OT applications. This is because the 5G network and the stack of cloud technologies it runs on is software-defined infrastructure built on the same software foundations – microservices and a service-based architecture – as OT applications are. 5G network functions can therefore be programmed and managed like OT applications and can interact directly with OT applications through APIs.

The software-based confluence between network services and application services enables the 5G network directly to participate in new application ecosystems on a SaaS basis. Microservices-based functionality is designed to be exposed and reused, so microservices-based network features and function can be exposed to developers for inclusion in developers' application pipelines. Since there are no limits to the functionality that can be developed in software or the ways in which functionality can be recombined with other functions, an NPaaS promises to boost innovation within an application ecosystem in ways that will be limited only by developers' imaginations.

For developers, the 5G network represents a new opportunity that is opening up to them beyond the limited set of functions exposed by CPaaS providers. While for CSPs, exposing all the new capabilities they are building into the 5G network through an NPaaS enables them to gain a much higher return on investment than simply selling business-as-usual, best effort connectivity services. This time round, CSPs will want actively to benefit from the new value creation opportunity provided by an NPaaS rather than conceding the market to third parties as they did with CPaaS.

The 5G network is an obvious starting point for an NPaaS because of its inherently cloud-native properties. However, there is no reason why the NPaaS concept cannot be applied to other network domains, including fixed access and transport networks and even legacy capabilities as CSPs extend softwareization activities in these areas too.

4.2 The NPaaS platform must be architected differently from CPaaS platforms to support the new use cases enabled by a cloud-native 5G network

An NPaaS shares the same objectives and principles as a CPaaS, that is, both platforms expose functionality implemented in multiple different ways through a common set of developer-friendly APIs. Both platforms aggregate functions from multiple CSPs so that developers need only develop to a single set of APIs that can call network services in any participating CSPs' network. CSPs that expose their 5G network assets through their own individual APIs would create walled gardens that could constrain the market.

However, there are three key differences between an NPaaS platform, with its broad and complex scope, and a CPaaS platform.

- **CPaaS platforms were built for a different era of networking.** The CPaaS concept is over a decade old and CPaaS provider platforms typically pre-date the softwareization of the network and the microservices-based foundation of the 5G network. They are therefore not built to support modern networks, modern application ecosystems and developers working with the emerging technologies that will be key to

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industrial, enterprise and consumer metaverse applications over the next decade. Some CPaaS platforms are likely to try and convert themselves into NPaaS platforms but their architecture may not be easily extended or optimized to expose cloud-native network assets.

- **CPaaS platforms handle a limited set of relatively simple functionality.** The voice, messaging, email and video functions that CPaaS platforms serve up through their APIs are discrete, bounded and mature capabilities that are straightforward to deliver and use, in a similar way, for example, to Google Maps or a payment service. These functions tend to be developed and managed by the same network organization responsible for communications services. CPaaS platforms may handle a high volume of API calls to these services, but these are simple, flow-through transactions.

  In contrast, the additional services that an NPaaS provide are inherently more complex and will involve co-ordination and collaboration between multiple facets and domains of the network in order to achieve, for example, end-to-end quality of service control or customized security features or latency-sensitive workload placement. This will require the platform to support the complex orchestration of low-level APIs in order to surface the application outcomes that developers request.

- **CPaaS platforms do not routinely provide intent-based interfaces**. Because of the simpler nature of the network services they expose, CPaaS platforms have little incentive to provide intent-based interfaces that enable developers to define at a high level, the capability they wish the platform to provide to their application. However, NPaaS platforms will support more complex orchestration of low-level APIs, potentially across network domains, so most developers will want such an interface: it will be critical to the NPaaS platform's ability to win the hearts and minds of a large developer community. An intent-based interface will allow the NPaaS platform to decide how to fulfil the developer's request by manipulating the right combination of low-level APIs, abstracting away their complexity. However, the platform must also enable network-savvy developers who may want to work directly with low-level APIs, using an SDK that allows them to specify the orchestration of selected APIs for themselves.

5. Conclusion and recommendations

A successful NPaaS platform will sit at the epicenter of an ecosystem that will bring value to all its stakeholders: CSPs that expose their network assets to the platform, developers that use the platform's APIs and enterprises that buy the applications that support their operational technology use cases of the future.

Stakeholders should therefore evaluate an NPaaS platform based on its ability to provide the following.

- **A wide range of network assets** that give developers choice and flexibility over the network functionality they can build into their applications. Such a range of assets will span network domains, enabling developers to control the network end-to-end.

- **Ease of API use**, to incentivize developers to build network capabilities into their applications. The NPaaS platform should allow different levels of access to network capabilities depending on the level of developer knowledge in order to capture as much of the developer ecosystem as possible. But simplicity should be the dominant theme at every level, especially because an NPaaS platform will be inherently more complex than a CPaaS platform.

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- **Resilient performance at scale.** The NPaaS platform must be able to execute its broad range of APIs in a timely manner and regardless of the number and complexity of the concurrent transactions it is asked to handle. The NPaaS platform must also be able to complete API calls that range from time-sensitive device location queries to the configuration of complex network policies, from complicated requests to create network slices with customized service operations to sophisticated queries of network data stores, from high volume calls to devices with diverse SIM card strategies to deterministic workload placement on the most appropriate (edge) resource. In the future, as AR/MR applications become more common, developers will want to take advantage of network sensing and mapping of locations in real-time, which will require the platform to process large amounts of data at high speed in order to deliver the right results to applications.

- **Extensibility** since Industry 4.0 applications are only just beginning to emerge and the requirements of future applications are not yet well-understood. An NPaaS platform should demonstrate a future-proof, cloud-native architecture that can support the leading-edge capabilities that are beginning to appear in 5G now and will continue to be rolled out towards 6G networks in the future, such as hyper-accurate positioning, ultra-low latency and the ability to connect, provision and manage hundreds of thousands of devices.

Developers, enterprises and CSPs all win when they collaborate through the right NPaaS platform that supports new Industry 4.0 needs and maximizes value creation for all.

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6. About the author

Caroline Chappell (Research Director) heads Analysys Mason's *Cloud* research 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.

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