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O₂ Telefónica Germany, Nokia 5G SA Core and AWS

Public cloud for telecom goes mainstream

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Introduction

Cloud computing is the single most disruptive innovation to have appeared in tech in at least the last 30 years, arguably longer. Yet cloud's potential to have a major impact on the telecom industry can often only come at the expense of thinking differently about long-held ideas and working practices.

That is not such a challenge for startup greenfield operators working to establish completely new modes of operation from Day 1. But wider industry change requires buy-in from the existing incumbents – the so-called brownfield operators - to new ideas and technologies. These companies have more to lose (an existing customer base, for one), so they are understandably cautious about change, let alone fundamental rethinks. Which is what makes O₂ Telefónica Germany's commitment to an AWS-hosted Nokia 5G SA core all the more remarkable.

> *"We are building our network of the future. With the launch of the new, cloud-based 5G core network, we are doing pioneering work in Europe and we are taking a major step in our transformation process. With the new 5G cloud core, we are moving away from traditional architectures and instead focusing on modern, high-performance, and efficient network technologies. In doing so, we are relying on the quality and global expertise of Nokia and AWS. We offer our customers an excellent 5G experience and new digital applications." - Mallik Rao, CTIO of O₂ Telefónica Germany.*

Telefónica is one of the world's leading telecom groups, with operations in a dozen countries including Spain, Germany, the UK, Brazil, and across Latin America. Calling telecom "the most powerful transformative platform on Earth", it has been investing continuously to build future-proof, resilient, reliable networks – more than €95 billion since 2012.

In Germany, O₂ Telefónica has led the development of mobile networks, accelerating the transition to each new generation of faster, higher-capacity, and more energy efficient network technologies. But it recognized early that 5G represents a more profound opportunity than any previous network generation. For both consumers and business customers, 5G offers not only greater speed and reliability, but more flexible, intelligent and secure digital services. However, realizing these benefits requires a fundamental change in approach, with cloud being central to O₂ Telefónica's vision of a flexible, efficient, automated, software-based network. In this vision, leveraging public cloud now checks the key boxes in a future-proof network strategy: on TCO, on security; on quality, performance and customer experience; on sustainability; on agility and ability to innovate.

Perhaps more so than any previous mobile network development program, O₂ Telefónica's move to cloud-native telecom has been a journey. A journey of thinking differently, a journey of innovation and collaboration, a journey where the destination is, truly, just the beginning.

O₂ Telefónica Germany is now the first major brownfield telco to run production traffic, at scale, through a 5G Core on AWS. O₂ Telefónica is initially moving 1 million of its wireless subscribers over to its AWS-based Nokia 5G SA core. This development comes after a long period of evaluation, consideration, technical challenge and innovation.

Appledore sees this as a significant industry milestone. In this Research Note we look at scope of this project, the relationship between **AWS** and **O₂ Telefónica Germany,** and its significance for the wider telecom industry.

About O₂ Telefónica Germany

In 2005, Telefónica acquired what was then O₂ Germany, as part of a wider deal to acquire mmO2 plc assets, formerly BT Wireless. In 2019, O₂ Telefónica Germany announced the rollout of 5G in five major cities. In 2020, it began using 5G SA technology in campus networks. In 2023, it launched 5G Standalone across its network as its "5G Plus" service.

By early 2024, its 5G network had reached 95% of Germany's 84 million population, with more than 10,000 5G base stations deployed (in a total mobile network of 28,000 sites). In Spring 2024, O₂ Telefónica Germany began to turn up open RAN sites for 4G and 5G.

Today, O₂ Telefónica is Germany's largest mobile provider, with over 45 million subscribers. O₂ Telefónica Germany provides both fixed and mobile services and devices to consumers and business customers, as well as hosting services.

Through 2024-26, O₂ Telefónica Germany will drive an Accelerated Growth and Efficiency Plan, including expansion of its business activities, state-of-the-art IT infrastructure and an ongoing commitment to a high-quality network.

Scope and Rationale

Under CTIO Mallik Rao, O₂ Telefónica has distinguished itself by driving a progressive agenda for its networks and operations since 2019 (in 2020, O₂ Telefónica Germany was the first German operator to build 5G on a cloud platform at scale). But the wider business goals behind this latest development will be familiar to any mobile operator:

1. **improve the customer experience** through faster updates and new service deployments.

2. **increase network agility and flexibility:** scale resources dynamically based on demand, leverage the expertise and capabilities of technology and Cloud partners.

3. **enable the development and delivery of innovative digital 5G applications**.

This new Nokia 5G Core deployment on AWS, one of the first of its kind for an established telecommunications provider, represents a significant step in O₂ Telefónica's digital transformation journey, as the company positions itself to meet the evolving needs of its customers and the broader 5G ecosystem.

As Rao stated in the [Telefónica press release](#): "We are building our network of the future. With the launch of the new, cloud-based 5G core network, we are doing pioneering work and are taking a major step in our transformation process. With the new 5G Cloud Core, we are moving away from traditional architectures and instead focusing on modern, high-performance, and efficient network

technologies. In doing so, we are relying on the quality and global expertise of Nokia and AWS. We offer our customers an excellent 5G experience and new digital applications."

As part of the business case for the project, O₂ Telefónica Germany built a multi-year TCO model, favorably comparing the cost of building, maintaining and operating an AWS-based Nokia 5GC solution against an on-prem, private cloud-based solution.

Solution Overview: A Public Cloud-Native 5G Core

O₂ Telefónica is running Nokia 5G Core at scale using AWS Region and Availability Zones constructs for a resilient and fault -tolerant architecture. O₂ Telefónica is initially migrating one million of its wireless subscribers to this 5G SA core.

The AWS-based Nokia 5G core network enables O₂ Telefónica to:

1. **simplify operations** through a combination of cloud automation frameworks and fully managed services. Telefónica will no longer need to do the non-differentiating heavy lifting of managing their own infrastructure and will benefit from mature third-party cloud automation tools and services.

2. **improve customer experience** through faster updates and new service deployments. Telefónica will be able to quickly test, integrate and deploy new applications and software upgrades. AWS fully managed services perform the undifferentiated heavy lifting of upgrading.

3. **increase network agility and flexibility** to scale resources dynamically based on demand. Telefónica will be able to scale resources in the cloud up and down dynamically based on actual traffic demands.

4. **quickly develop and deliver** new and innovative digital 5G applications. Telefónica will be able to leverage AWS's broadest and deepest set of services, including Gen AI, AI/ML, analytics and quantum computing, to build new application and services.

Customers will experience reliable connectivity and fast speeds using the O₂ Telefónica 5G Standalone network ("5G Plus"), ensuring optimal performance, always available resources, resilient services, and faster software enhancements.

Having the Nokia 5G Core on AWS means there is *no physical core network infrastructure* required for this core – only equipment at its RAN sites as well as for transport of data and internet peering.

Perhaps most importantly, the new solution accelerates Telefónica's ability to quickly launch new offerings to the market, thanks to elasticity, scalability and cloud automation.

The 5G core architecture will evolve over time, with Nokia's high-throughput user plane function (UPF) moving to AWS Outpost racks in O₂ Telefónica datacenters, while the control plane (CPF) stays in the AWS Region. This hybrid deployment model can be used to reduce latency for 5G customers. A partially on-prem deployment option is important since it allows O₂ Telefónica to utilize the existing investments in internet breakout locations and caching.

The three-way partnership with AWS and Nokia also opens up new revenue opportunities for O₂ Telefónica. For example, AWS, Nokia and O₂ Telefónica have already partnered on exposing 5G SA network capabilities as APIs and making them consumable in the AWS developer ecosystem. This allows 5G network features such as Quality of Service, latency, mobility to be combined with enterprise and consumer applications and monetized in an incremental revenue stream.

AWS Services

Among the AWS services used by O₂ Telefónica in this architecture are:

- **Amazon Elastic Kubernetes Service (EKS)** for the orchestration of microservices-based Network Functions (NFs) from Nokia.

- **Elastic Cloud Compute (EC2)** for different types of workloads ranging from compute intensive to network throughput intensive.

- **Amazon Virtual Private Cloud (VPC)** for IP networking between different NFs on AWS and across on-premises at scale.

- **AWS Direct Connect** for high performance, secure and resilient connectivity to on-premises central and edge sites such as Radio Access Networks (RAN) sites.

- **Amazon Elastic Block Storage (EBS)** and **Amazon Elastic File Storage (EFS)** for resilient and performant block and network attached storage respectively.

- **Amazon Key Management Service (KMS)** with **Amazon Cloud Hardware Security Module** (HSM) or **AWS KMS XKS** for management of data encryption keys using fully managed and dedicated tamper-resistant hardware device to secure customer data

- **AWS Control Tower** for consistent and scalable governance of AWS accounts and organizational policies

In the future, O₂ Telefónica may also benefit from AWS suite of Cloud automation services like Continuous Integration/Continuous Deployment (CI/CD) services for automated and Infrastructure-as-Code (IaC) based lifecycle management of the 5G Network Functions to further improve the time-to-market.

Key Factors

Brownfield operators are particularly concerned about ensuring that any changes to network technology or operating processes do not compromise the hard-won trust of customers (and regulators). In order to secure and execute this 5G core network cloud migration engagement, AWS had to overcome a number of commercial and operational concerns, including:

- **Network Resilience in the Cloud:** O2 Telefónica, Nokia and AWS have architected a highly available and resilient network in the AWS-cloud. Leveraging the region and availability zones. In future, Outposts will be added in multiple datacenters from O₂ Telefónica to further extend the setup.
- **A cloud consumption model:** AWS and Nokia have provided a mechanism to O₂ Telefónica that allows them to scale UPF capacity in an elastic manner that is consistent with their broader cloud consumption model.
- **Network Security:** Telefónica, Nokia and AWS have built the security framework on two main pillars:
  - verifiable control over data access
  - the ability to encrypt data with the key ownership staying within Telefónica. AWS Provides Data protection features, such as data encryption at-rest, in-transit and in-use, accreditation and contractual commitments on verifiable control.

On network and data security, the German context and how AWS and Telefónica O₂ addressed the challenges is especially worth understanding.

Security & Data Sovereignty

Among European countries, Germany has been the most progressive in setting out requirements and obligations in relation to data. Its first Data Protection Act dates from 1978. In 2018, Germany was first to implement GDPR legislation. In 2021, the German government set out a [Data Strategy](#) with over 240 measures, aimed at making data infrastructure effective while still supporting innovation, setting out responsible uses of data, and ensuring that governments would take a leading role in data governance and security.

Data localization laws insist that certain data originating in Germany remains within the country, though some data is permitted to be transferred within the EU with an approved data security environment. The explicit consent of individuals to such data transfers or other data processing is an integral part of the legislation.

Penalties for data management breaches are significant: up to EUR20 million or 4 percent of annual global turnover. Even the failure to notify the authorities of data breaches in a timely fashion – within 72 hours - carries a fine: up to €10m.

Against this backdrop that O₂ Telefónica Germany has been developing its strategy for growth, innovation, expansion and IT transformation.

AWS & Data Sovereignty

AWS has been focusing on digital sovereignty since the mid-2000s. They made an early design decision to make AWS regions self-contained, initially to minimize the risk of data failures in a region-agnostic global cloud. Data sovereignty is now a commitment that AWS makes to its customers and in-country regulators.

AWS also calls out **Nitro** as a key differentiator and as evidence of its distinct sovereignty-by-design pledge. Nitro is a combined hardware/software hypervisor component within the AWS infrastructure. Nitro takes a range of virtualization management and security functions from the host server CPU, offering greater control at a deeper level in the infrastructure than a conventional software hypervisor in a hyperscale cloud. AWS's data and its customers' data are kept completely isolated from one another. Nitro extends the same level of data security that exists within AWS's own datacenters all the way to its customers' premises. Nitro now comprises several components, which together speak to what AWS refers to as "confidential computing" – ensuring the security of data in use, not only in transit or at rest.

In May 2023, AWS Nitro [achieved independent third-party validation by NCC Group](#).

5G Core Automation and AWS Security

Using hyperscale cloud infrastructure goes hand in hand with automation. Nokia Cloud Operations Manager (NCOM) automates the lifecycle of containerized network functions (CNFs) and network services. NCOM provides automation of CNF workloads and the CNF's cloud infrastructure, allowing the full chain of automation for service delivery.

Automation is a good example of where AWS, Nokia and O₂ Telefónica will continue to evaluate, adapt and iterate to ensure an optimal solution and division of responsibilities.

O₂ Telefónica is clear about the need to build in full automation – not partial – from Day 1. AWS Landing Zones have been a foundational component for locating telco workloads. The potential is to use automation to locate (relocate) workloads to the network edge, where that offers the optimal tradeoff between performance, latency, cost. Additionally, edge network functions (RAN functions) can be brought back to the corporate data centers or AWS cloud, according to need.

Partnership

This development at O₂ Telefónica Germany is also notable for the three-way partnership between AWS, Nokia and O₂ Telefónica.

At O₂ Telefónica Germany, AWS and Nokia have been working closely together to adapt and validate a cloud-based 5G Core. Not only from a performance perspective, but also in terms of operational processes.

For Nokia, this means being able to use the same source code for its 5G Core in an on-cloud deployment as for any other deployment – simplifying its own product development and support, while ensuring consistency in capabilities, performance, security and so on.

AWS in Telco

AWS has been responsive to the distinct needs of telecom operators considering using hyperscale cloud infrastructure for telecom-specific workloads. Telcos were a strong inspiration in the creation of AWS Outposts, for example. But the arrival of 5G opened a new field of opportunity for telcos and hyperscalers alike: a fully software-ized network architecture not only designed to be run on distributed infrastructure, but also designed to be easier to upgrade – through software updates.

The paradigm of (almost) "everything as software" is a radically different one for telecom. It offers accelerated time-to-market, greater variety and potential for innovation, and automation. But it also requires telcos to adopt a mindset and working practices that, while now common in enterprise IT, are less familiar to network engineers.

Cloud-native telecom pioneers like **Dish Network** and **Rakuten Mobile** have been all-in on the cloud from Day 1 (and Dish is reported to be AWS's largest customer in North America). But for established operators, the changes required to existing procedures, technologies, skill sets and policies are inevitably more difficult to make. And new skills must be learned – even by telecom experts with thirty-plus years of experience behind them.

In February 2024, **NTT DoCoMo** announced plans to use AWS container management software (Amazon EKS Anywhere) for its 5G Open RAN software. Until now, NTT DoCoMo's 5G core has been running on a hybrid cloud. But after trials in 2022, NTT proved significant reductions in power consumption (72%) for its 5G Core software, using AWS Graviton processors, and carrier-grade resilience design that can switch network workloads seamlessly between NTT on-prem and AWS environments. In Japan, where earthquakes are common, network resilience is a key concern.

AWS has worked in recent years to smooth the path to cloud-based telecom in several ways:

- Working with leading **telco-specialist ISVs** to make their software cloud-native, and available on AWS. For example, Nokia's 5G RAN software.

- Establishing a single, coherent continuum of telco-grade cloud infrastructure spanning network edge to core, with common management tools and automated processes.

- Incorporation of **telecom-specific hardware** into AWS EC2 instances – such as Nokia's Cloud RAN Smart NIC (this uses an Arm-based silicon and in-line architecture to run compute-intensive Layer 1 functions).

- The **AWS Telco Network Builder** (TNB) – a service that automates the build and deployment of cloud infrastructure resources appropriate to the demands of a given network function.

- Telecom specialists in its **professional services** team, who work with CSP customers to plan effective migration to AWS.

As an example of that, Appledore notes the early 2024 announcements of deals between AWS and **TELUS**, and with **BICS** in Belgium, and partner **Samsung:** customers traveling to other countries can connect to their home operator's mobile network – via a local AWS Region, not only avoiding expensive roaming charges, but having the same network quality and capabilities as at home. This "virtual roaming" capability is one example of a completely new value proposition.

Such developments represent a constant pushing back of the perceived limitations of cloud, and as such, are welcome developments for an industry still trying to chart an effective path back to growth.

Appledore Analysis

Telecom has had a somewhat cautious relationship to date with cloud in general and hyperscale public cloud in particular. While a small number of pioneering operators (Dish, Rakuten) have proven what is possible, existing service providers have proceeded with care, seeking assurances in areas where they see telecom as having uniquely demanding requirements.

Two aspects of telecom that remain non-negotiable in the era of cloud. First is **security**. Telecom networks are critical national infrastructure and states rightly insist on the highest possible security to protect their networks. Individuals likewise expect service providers to ensure that both their transmitted data, as well as many other personal account information, is held securely and used responsibly. Telecom operators' customer relationships are founded on trust.

Second is **performance**. No innovation attempting to gain a foothold in telecom – not cloud, not AI – will succeed if it reduces network service performance experienced by customers. There is always room to improve – but there is no room to go backwards.

In addition to its many other challenges (scale, competition, regulation, complexity, market economics!...) the absolute priority for security and performance are what makes telecom especially demanding for technology innovators.

Nonetheless, the rewards for telecom in embracing cloud are compelling to incumbent telcos: significant reductions in capital and operating expenses, greater agility in responding to customer requests and market shifts, improved productivity and innovation. And those are just the beginning.

We believe that the relationship between not just cloud but *hyperscale* cloud and telcos is entering a new phase. Quick early wins – the low-hanging fruit opportunities for both sides – have been made. Now, over the last couple of years, the conversations between hyperscalers and telcos have taken a much more strategic turn. In particular, thanks to progress made in meeting operators' non-negotiable demands – in the cloud.

Conclusion

The 5G core project between AWS, Nokia and O₂ Telefónica is a significant industry development, for several reasons.

First, we believe it represents the largest relocation of current subscribers from an on-prem 5G core to a truly cloud-based platform, with infrastructure, compute and storage resources consumed on-demand.

Second, it indicates the progress made by AWS in adapting its offering to meet the needs of telco. Part of telecom's early wariness on cloud was precisely based on a perception that the hyperscale cloud business model depended on it *not* accommodating industry-specific requirements. We are now seeing some softening of that. Clearly, AWS has worked closely with key telco vendors – **Nokia, Ericsson, Samsung, NEC, Mavenir, Juniper** and many others – to prove that their critical functions perform at least as well in the AWS as in a traditional data center. But that is only table stakes. The upside is in the extra resilience, flexibility, automation that public cloud can provide. It is clear that O₂ Telefónica has its sights set on those benefits.

Third, language from O₂ Telefónica Germany indicates that this move is about growth and agility, more than cost reduction. Being on AWS specifically opens new possibilities – not least in terms of creating, introducing and scaling new service mashups: faster, easier innovation and experimentation are integral to telcos' efforts to find new revenue opportunities.

Fourth: it demonstrates how the conventional relationship between telcos and their primary network suppliers is evolving. Until recently, the most significant change that telcos wanted in the vendor landscape was an additional (and largely equivalent) alternative vendor to buy from. But the cloudification of telecom offers much more, in return for more multi-party projects.

This commitment to AWS by the largest German mobile operator, owned by the Spanish incumbent, in partnership with a globally successful Finnish vendor, is the strongest evidence yet that cloud-native need not be an option reserved only for pioneers and risk-takers – but is **rapidly becoming a pragmatic and compelling option for brownfield operators**. As CTIO Malik Rao put it in an interview with Reuters: "the days of trial are over. I don't want to keep on trying."

Pioneers like Dish and Rakuten don't always become the template that others adopt. Seeing a large peer provider like O₂ Telefónica make a strategic shift is a far more powerful influence on mainstream telecom.

Insight and analysis for telecom transformation.

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