Telco Cloud Operator Profiles

Telco Cloud

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Our Telco Cloud Operator Profiles present the network virtualisation strategies of selected operators. Their aim is to provide a picture in 'plain English' of these companies' progress in their virtualisation journeys: how they have evolved since they first started and where they are heading, who their key vendors and partners are, and STL Partners' perspective on their transformation.

Our profiles leverage information from our Telco Cloud Deployment Tracker and reading them with the tracker spreadsheet filtered on the profiled operators will give the reader additional and valuable context.

Operators can use the profiles to learn about other players' best practice examples and key vendor partners. They can compare their own strategies and learn from others with similar size, operations and market characteristics.

Technology providers can use the profiles to understand the key drivers and challenges which telcos face with telco cloud and how to position their solutions and services to help them achieve their goals.

In the coming months, we will add profiles so that we continue to illustrate a wide range of telco cloud strategies, operator types, and regions.

In this first set of profiles, we cover four operators:

- Telenor
- Axiata
- Turkcell
- AT&T.

Each profile starts by outlining the major milestones in the operator's telco cloud journey. It then provides details of the operator's deployments across network domains, focusing on the RAN, core, and cloud infrastructure. It concludes with an assessment of the operator's overall telco cloud journey so far and its outlook. All acronyms used in this report are presented in a glossary.

Please get in touch to provide your feedback (including suggestions about which operator(s) to profile next) to ahmed.ali@stlpartners.com.

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Telco cloud is a journey and we use pathways to illustrate how telcos navigate it

- This document, containing our first set of Operator Profiles, uses a set of pathways to illustrate where each operator is at in terms of telco cloud. We first introduced the pathways in our 2021 Telco Cloud Manifesto, and at the time we had three pathways. In our profiles, we have refined our pathway model and increased them to four (essentially creating a fourth pathway to separate out fully cloud-native, infrastructure-independent telcos, such as AT&T). We define our four pathways on slides 8–13, and each operator-specific profile explains why a given pathway has been assigned to that particular telco.
- In summary, these profiles show that:
  - **Telenor** (identified as a Pathway 1 operator) collaborated closely with Nokia, then Ericsson, in such a way as to avoid lock-in and enable other vendors to integrate their solutions down the line. This strategy has worked well, e.g. enabling Telenor to achieve a high level of automation in its Nordic footprint.
  - **Axiata**'s cost-driven, connectivity-focused telco cloud strategy employed a multi-vendor + systems integrator approach from the start. This allowed it to choose the most relevant set of vendors and optimise its assets in each of its national markets. We identify Axiata as a Pathway 2 operator.
  - **Turkcell** (identified as a Pathway 3 operator) has built a horizontal platform with an increasingly diversified set of vendors providing network functions on top of it. It has relied heavily on Affirmed Networks and developed its own internal telco cloud skillset, allowing it to take better control over its own platform and CNFs.
  - **AT&T** (identified as a Pathway 4 operator) was a pioneer of telco cloud whose journey started in 2014 with a preference for open-source, sometimes internally-built, solutions. These later evolved into a cloud-native platform that was scalable and robust enough to be taken over by a hyperscaler, Microsoft Azure in June 2021. AT&T represents the North Star of what telco cloud can achieve when telcos dispense with their own virtual and/or physical cloud infrastructure altogether and focus on meeting the needs of specific use cases.
- *Please note: we use pathways as the best overall characterisation of an operator's virtualisation stage at a given point. Many operators develop between pathways over time, giving themselves greater flexibility and control, as well as wider commercial and technical options*.

Our Operator Profiles show that telco cloud is a worthwhile effort and an integral part of telcos' transformation

- Telco cloud – the virtualisation and cloudification of network functions and infrastructure – has been at the heart of telcos' operational and organisational transformation since the mid-2010s, with the aim of achieving three main benefits:
  - creating a platform for innovation, through more programmable, flexible and scalable networking capabilities
  - increased agility, lowering time to market for new services
  - lower TCO, through more efficient use of resources, automation and use of COTS rather than proprietary hardware.
- Our recent report Telco Cloud: Short-term pain, long-term gain showed that telcos remain committed to telco cloud even if some of the benefits remain elusive. They see it as a key aspect of their technological and organisational transformation, and of their ability to compete in an increasingly software-driven marketplace.
- Next steps:
  - In the coming months, we will increase the coverage of our Operator Profiles to further illustrate our four pathways
  - We will also complement them and our overall telco cloud research with a Telco Cloud RoI tool whose aim will be to quantify the economic benefits of telco cloud.

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What are the different telco cloud pathways for operators?

It is our view that the move to increasingly virtualised telco networks is inevitable. We have discussed the reasons for this throughout our telco cloud research and reports since 2013–4 at the start of what was then known as NFV (see our glossary of acronyms). In essence, the old world of appliances dedicated to particular logical network functions is being replaced by software functions running over COTS hardware.

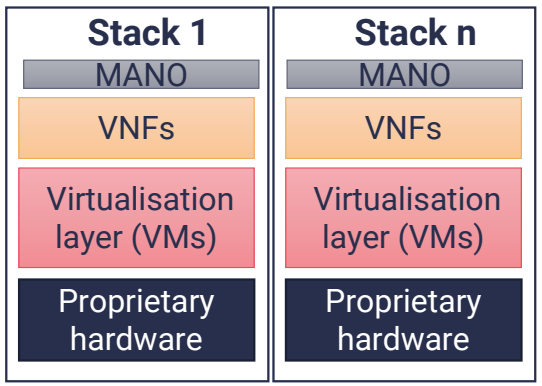
However, the end goals for this process and the pathways for getting there vary widely from operator to operator. The trigger to virtualisation for many Pathway 1 operators is when they want to deploy the latest versions of network functions and find that most vendors only supply these (e.g. EPC (4G core) or 5G NSA core) as VNFs. Pathway 1 players tend to deploy these VNFs as single-vendor, full-stack solutions, complete with the orchestration and virtualisation layers[1] from the same vendor. At the other end of the scale, Pathway 4 operators have fully evolved to cloud-based operations and CNFs; they design and deliver network functions from any cloud without needing to own the infrastructure or platform involved.

Most operators of any scale in developed markets are currently taking an approach between these two extremes (Pathways 2 and 3): developing multi-vendor networks delivered over horizontal telco cloud platforms, and either relying on vendor and SI partner support to help integrate the solutions (Pathway 2), or taking charge of this process themselves (Pathway 3). We illustrate and discuss below these four pathways and some of the considerations for operators adopting each model.

Pathway 1

Single-vendor/ full-stack

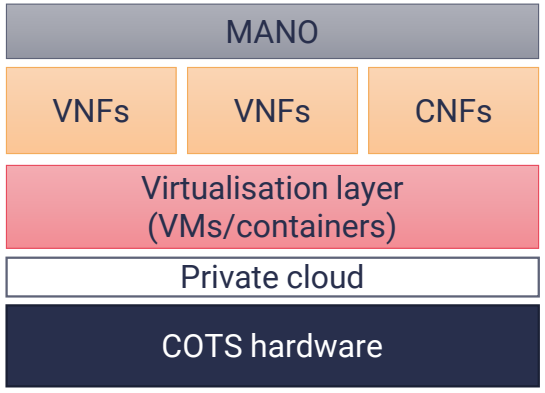
Operators deploy siloed vertical solutions using vendor one-stop shop for hardware, platforms & applications and it is semi-open with vertical integration



Pathway 2

Vendor-supported best-of-breed

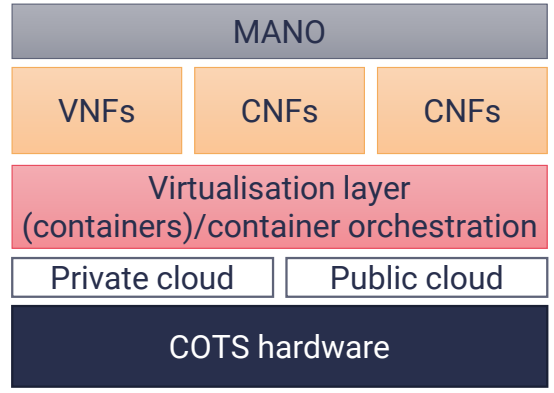
Operators leverage COTS hardware with the support of a vendor / system integrator to run enabling platforms and VNFs from a collection of vendors



Pathway 3

DIY best-of-breed

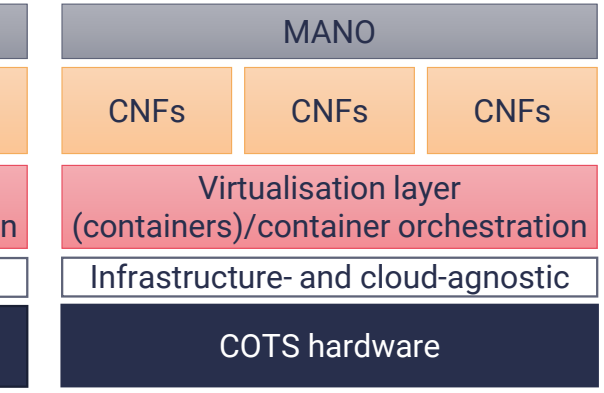
Operators build and integrate their own platforms and VNFs/CNFs using components from multiple vendors and hybrid cloud infrastructure



Pathway 4

Non-proprietary cloud-native

Agile CNF development, deployment and operation over cloud-agnostic infrastructure and in a multi-vendor environment

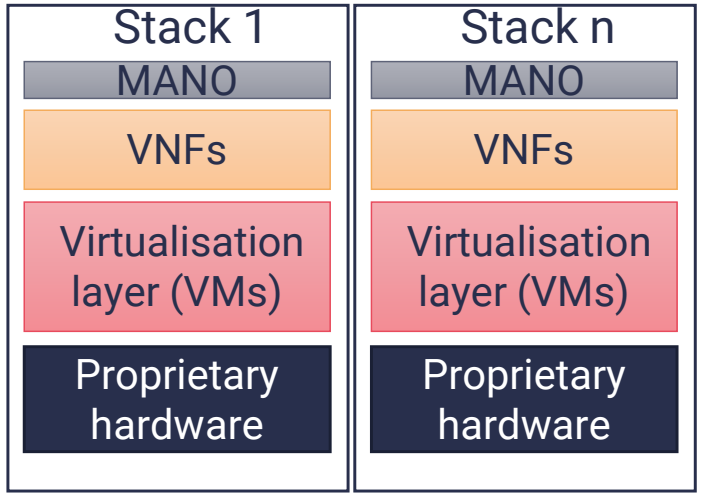


[1] The virtualisation layer may be VMs or Bare Metal (containers only).

Pathway 1: Single-vendor/ full-stack

Telco cloud adoption model

- Siloed vertical solutions - vendor one-stop shop – hardware, platforms, and applications likely to be provided by a single vendor per stack
- Semi-open only and likely to have some vertical integration (not a pure-play decoupling of layers)



Key considerations

- Pathway 1 may be the starting point for many operators that currently lack relevant internal skills and expertise, but it should not be the ultimate destination.
- Operators who see Pathway 1 as the destination will be dependent on the vendor's innovation cycles, which ultimately constrains innovation. This will make it much harder for them to pursue revenue beyond connectivity.
- They will also lack vendor competition and therefore may experience lower quality through the stack and higher costs.
- Operators should work with vendors that provide a genuine roadmap for reaching Pathway 2 and 3 and hold them to account for this via contracts. For example, secure a contractual obligation from the vendor that their components interoperate with those from other vendors with whom operators may seek to engage in future. Our Telenor profile provides an example of how following a Pathway 1 approach can still open up to a multi-vendor environment down the line.

Operator characteristics

- Resource-constrained operators with limited internal IT/cloud and system integration capabilities
- Many Tier 2s and 3s (including MVNOs) worldwide
- Some Tier 1s in developing markets

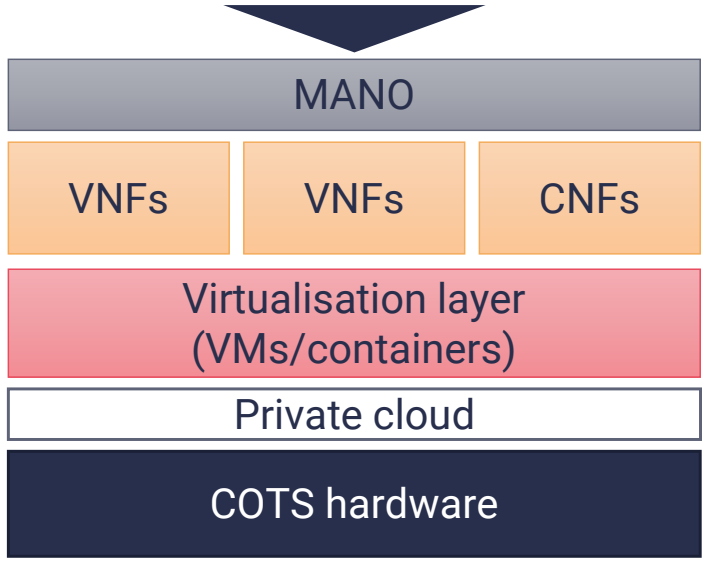
Examples

SFR
SaskTel
stc
telenor
Telkom Indonesia

Pathway 2: Vendor-supported best-of-breed

Telco cloud adoption model

- Disaggregated stacks. VNFs decomposed into microservices (allowing a multi-vendor environment). Solutions are pre-integrated and any remaining integration is dealt with by lead vendor / SI
- COTS hardware. Enabling platforms, certification of hardware and VNFs/CNFs provided by one or more vendor ecosystems
- Vendor / SI integration and support



Key considerations

- This pathway is about enabling a more open, vendor ecosystem to foster innovation across the stack. Telcos on Pathway 2 have made progress in decoupling software from the underlying hardware and virtualising NFs so that they can run as software on COTS hardware.
- Many Pathway 2 operators cite challenges around not having the right skills and people to manage this complexity. Therefore, vendors must still commit to and provide pre-testing and pre-certification to ensure that operators have greater freedom of choice in terms of VNFs that sit on top of their NFVi, whilst operators must take an 'integration by design' approach and push for greater standardisation in their architecture.
- Operators have also cited challenges with establishing accountability with vendor partners when issues arise. This presents an opportunity for SIs to support those progressing from Pathway 1 to Pathway 2. Regardless of whether an SI is involved, operators should take greater ownership to understand what is happening in their plumbing in order to build greater know-how and experience.

Operator characteristics

- Most Tier 1s and some Tier 2s (larger MNOs and MNO groups), including some that claim their approach is fully cloud-native (which Pathway 2 generally is not)
- Growing IT/cloud competence with the aid of system integrators, but with more limited resources than Pathway 3

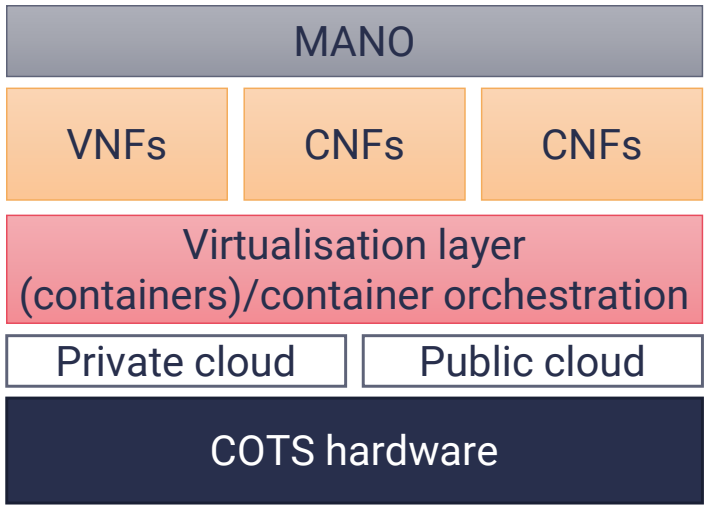
Examples

BT
América Móvil
Singtel
TELSTRA
axiata

Pathway 3: DIY best-of-breed

Telco cloud adoption model

- Move to a more open, best-of-breed, multi-vendor ecosystem for greater innovation.
- COTS hardware, hybrid enabling platforms (private & public cloud), plug & play VNFs/ CNFs provided by best-of-breed vendors
- Telco as its own SI managing implementation and integration



Key considerations

- Moving on from Pathway 2 where integration was a major activity, Pathway 3 is an environment where interoperability is improved across different components of the stack, thanks to the existence of, and compliance with, standards.
- But we recognise that this is not a realistic starting point for most operators, given legacy challenges and a lack of the right expertise, skills and resources to do it.
- Operators in this pathway are large and powerful but still need to work together to ensure that vendors conform to open standards – they should be participating actively in standards bodies and seek to share open-source code with each other.

Operator characteristics

- Mostly Tier 1s: leading players in large domestic markets (such as the US, China, Japan, etc.); or European operator groups with subsidiaries in multiple markets
- Resources and capabilities to take on major transformation programmes involving significant IT/cloud requirements and substantial integration

Examples

Rakuten Mobile
TURKCELL
vodafone
verizon
Deutsche Telekom
Telefónica
SK telecom

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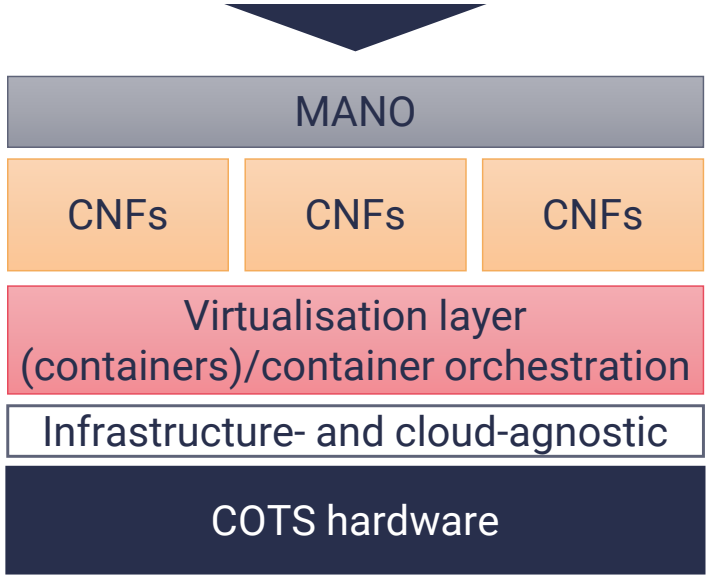
Pathway 4: Non-proprietary cloud-native

Telco cloud adoption model

- Fully cloud-native: true microservices architecture, containers, CI / CD
- COTS hardware
- Agile CNF development, deployment and operation over multi-cloud infrastructure
- Telco as its own SI



Key considerations

- Operators on this pathway partner with hyperscalers to deploy CNFs on their infrastructure, instead of, or in addition to, telco's own private cloud and facilities.
- Potentially dispense with ownership and operation of private cloud platform and physical cloud infrastructure altogether
- Risk of operator becoming dependent on hyperscaler innovation cycle and its ability/willingness to develop a rich partner ecosystem
- However, if true cloud-native software design principles are followed, CNFs should be portable across any cloud: cost-efficient, agile operations; NFs and services delivered like any other SaaS or IaaS.
- Flexible, scalable, customisable and programmable network functions adapted to the needs of specific use cases

Operator characteristics

- Select group of Tier 1s or greenfield operators (thinking of) building part or all of their network functions in the cloud, inc. public cloud
- Resources and capabilities to take on major transformation programmes involving significant IT/Cloud requirements and substantial integration

Examples

AT&T

dish

Benefits and risks of each pathway

Pathway 1
Single-vendor/ full-stack

Pathway 2
Vendor-supported best-of-breed

Pathway 3
DIY best-of-breed

Pathway 4
Non-proprietary cloud-native

Benefits

• Supporting faster deployment with the help of a vendor integrator • Might be a cost-effective option for operators with limited resources and expertise	• Offering more control and flexibility for telcos (compared to Pathway 1) to shape and expand their stacks according to their needs • Gives telcos the opportunity to build greater knowledge and experience	• Allowing a more open stack and greater innovation (compared to Pathway 2) • Providing stacks that are more interoperable and compliant with standards	• Establishing higher levels of flexibility and scalability, with fully cloud-native stack and functions that can adapt to use cases • Cost-efficient, agile operations, and deployment can be carried out over any cloud and multi-cloud infrastructure

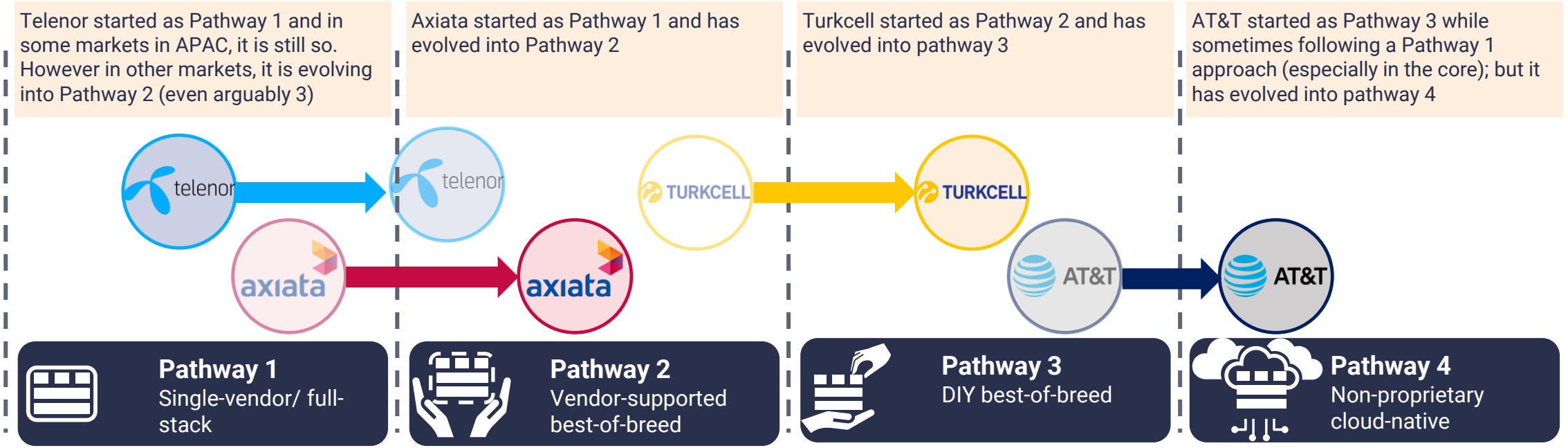
Risks and concerns

• Relying on vendor innovation cycle with limited revenue opportunity beyond connectivity • The lack of vendor competition can ultimately drive higher-cost and lower-quality components	• Ensuring interoperability among vendors with pre-testing and pre-certification • Establishing accountability with vendors when issues arise • Acquiring the right skills and people to manage the complexity.	• Investing time and effort to maintain high level of collaboration and active participation in open-source initiatives and standardisation • Investing in acquiring and maintaining resources and capabilities to deliver and manage the requirements across the stack	• Once migrated to public cloud, operator risks becoming dependent on hyperscaler innovation cycle and its ability and willingness to develop a sufficiently rich partner ecosystem

Operators evolve across the pathways

For the purposes of this document, and as per our Telco Cloud Manifesto (published in 2021), our pathways illustrate typical approaches to Telco Cloud. The purpose of the pathways is to conceptualise the most distinctive stages in virtualisation and understand in simple terms where telcos 'are at'. There are three caveats to this approach:

1. The pathways are simplifications and cannot reflect all the nuances of telcos' actual journeys. E.g. telcos within the same pathway may differ significantly in their approach to different network domains (e.g. core vs RAN)
2. Second, telcos are on an evolutionary path, and their position in relation to the pathways changes over time. Typically we expect a telco to start in one pathway and mature on to higher pathways as part of a continuous process
3. Owing to this complexity and evolution over time, deployments may in reality take more of a hybrid form: e.g. COTS instead of proprietary hardware (Pathway 1); or containers deployed over VMs rather than bare metal in Pathways 2 to 4.



Implications for vendors: Operators won't stand still, so neither should you

- The four telcos featured in our Operator Profiles each illustrate one of the four pathways we believe telcos are following in their telco cloud journey. But they also illustrate what we say in the previous slide, which is that operators are ultimately on a journey from one pathway to another as their engagement in telco cloud becomes more and more transformative – technologically and organisationally.
- When vendors are targeting prospective telco clients for their VNFs and cloud platform products, it is essential that they understand both the stage the telco is at in its journey, and how that journey is likely to progress next – i.e which pathway, or blend of the components of each pathway, is likely to be more appropriate for it at any stage.
- Therefore, it is vital, when responding to telcos' RFPs, that vendors set out not just how their solution fulfils the limited set of short-term requirements that telcos have specified, but also the development roadmap: how the solution will evolve and adapt to deliver on their clients' changing needs as they become increasingly cloud-centric and cloud-native.
- For example, this might involve elaborating how a relatively full-stack, monolithic VNF such as a 5G NSA core (typical in a Pathway 1) might evolve to become a more cloud-native, open, flexible and multi-vendor solution as the operator migrates to 5G SA, and explores new vertical- and enterprise-specific use cases enabled by edge computing.
- Vendors must also position themselves as a trusted partners to telcos help them address the complexities of multi-vendor solutions (in the context of vendor-supported best-of-breed deployments – our Pathway 2); and also as a partners assisting telcos to evolve their own software-development and cloud practices, including the ability to adapt, develop and reintegrate vendors' solutions as part of DevOps and CI/CD processes across the private cloud, or any cloud (Pathways 3 and 4).

Glossary of acronyms

Acronym	Definition
5G NSA	5G Non-standalone
5G SA	5G Standalone
BSS	Business Support Systems
CI/CD	Continuous Integration / Continuous Delivery
CNF	Cloud-native network function
COTS	Commercial off-the-shelf
CPE	Customer premises equipment
C-RAN	Cloud RAN
CUPS	Control and User Plane Separation
EPC	Evolved Packet Core

Acronym	Definition
Gi-LAN	Gateway Internet for Local Access Network
HLR / HSS	Home Location Register / Home Subscriber Server
IMS	IP Multimedia Subsystem
MANO	Management and Orchestration
NAT	Network Address Translation
NF	Network function
NFV	Network Functions Virtualisation
NFVi	NFV Infrastructure
OSS	Operations Support Systems
PCRF	Policy Charging Rules Function

Acronym	Definition
PoP	Point of presence
RAN	Radio Access Network
SBC	Session Border Controller
SBG	Session Border Gateway
SDN	Software-defined networking
SD-WAN	Software-defined Wide Area Network
SI	Systems integrator
VIM	Virtualized Infrastructure Manager
VM	Virtual Machine
VNF	Virtualised Network Function
VPC	Virtualised Packet Core
vRAN	Virtualised RAN

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Telenor: An innovative Pathway 1 player

Pathway 1

Originally Norway's incumbent operator, Telenor has become a global telecoms provider operating in the Nordics (Denmark, Sweden, Finland (as DNA) and Norway) and APAC (Bangladesh (Grameenphone), Malaysia (DiGi), Pakistan, and Thailand (dtac)). It started divesting its Myanmar operation in March 2022. In Thailand, Telenor is seeking regulatory approval for dtac to merge with second-ranked operator truephone. In 2021, Telenor had total revenue of USD11.3bn and ca. 172m[2] subscribers.

We classify Telenor as a Pathway 1 operator because its initial NFV deployments relied mostly on Nokia orchestration and cloud platform components. However, Telenor's approach was also untypical of Pathway 1, in that it deployed Nokia's and other vendors' VNFs on top of the Nokia platform. In our view, this makes it an exemplary Pathway 1 player that seeks to be innovative and agile within the constraints of this pathway (i.e. being closely tied to Nokia in particular, and Ericsson). In other words, Telenor has strived to retain enough flexibility to embrace a multi-vendor approach later on.

2017 Innovative P1-type approach during VM-based VNF phase

- Telenor deployed a telco cloud platform whose components (MANO, NFVi, and hardware) are supplied by **Nokia** in the Nordics and its APAC markets.
- However, Telenor's Pathway 1 approach is unusual and innovative, in that it adapted Nokia's telco cloud platform (a proprietary version of **OpenStack** optimised for Nokia VNFs) to support core VNFs from other vendors.
- In 2018, **ZTE** provided the EPC in Pakistan.
- A similar approach was likely followed in the Nordics with **Ericsson** an alternative supplier of VNFs; as the next steps in Telenor's story suggest.

2019 5G rollouts in Europe brings the proof point of Telenor's hybrid approach

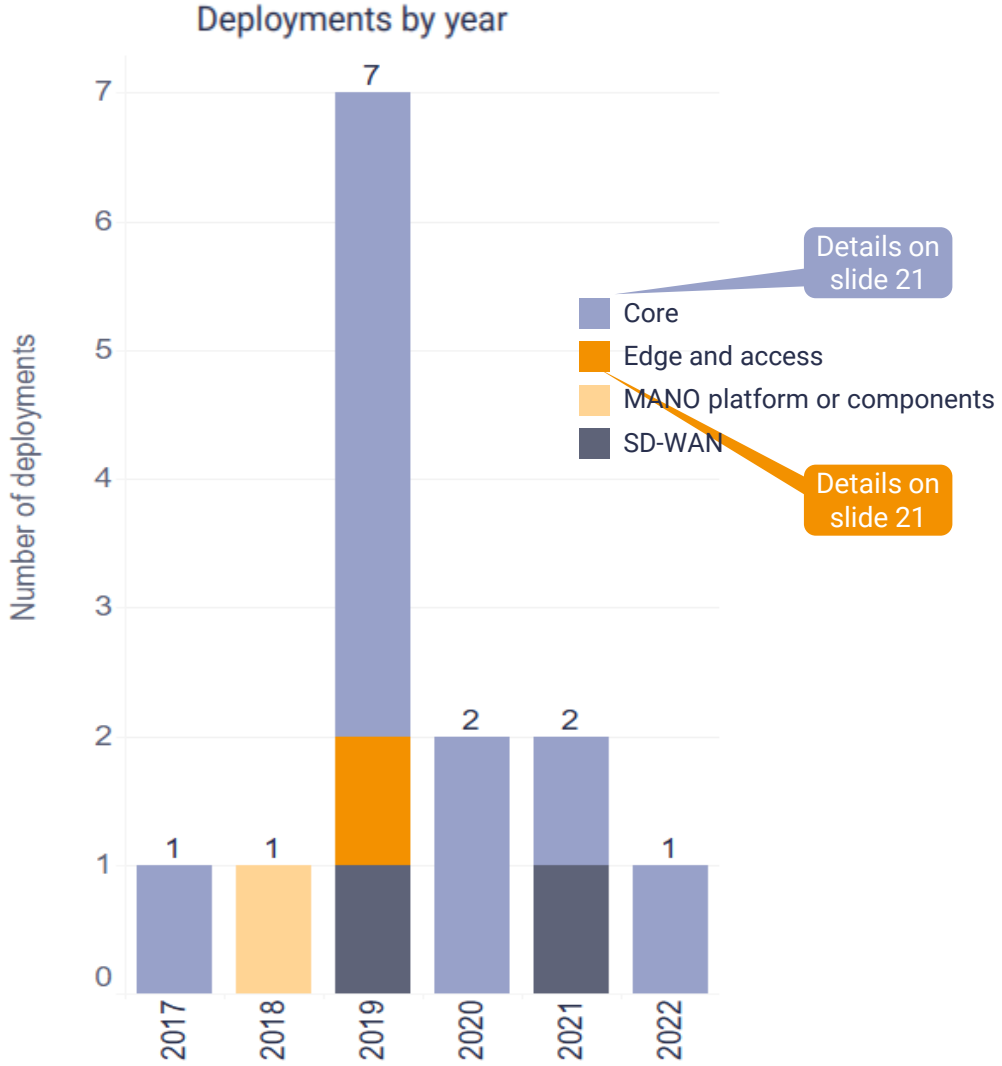
- During 2019–2020, Telenor deployed 5G NSA core networks in Norway, Denmark and Sweden using **Ericsson** and **Nokia** VNFs on Nokia's cloud platform.
- This was a unique approach designed to allow Ericsson and Nokia VNFs to be deployed in a flexible, scalable, distributed, and more densely multi-vendor way. In Telenor's whole Nordic footprint, the intent was to support 5G performance requirements and emerging use cases.
- In Finland, Telenor acquired a controlling stake in DNA in August 2019. DNA had launched a converged 5G NSA / SA core based on **Affirmed Networks**, presumably also running on top of the vendor-neutral Nokia platform at the start of 2019. A 5G SA launch later in 2019 was a world-first.

2022 European 5G SA core networks are developed in multi-vendor environments

- 5G SA core trials are underway in Denmark with a long list of vendors including: **Oracle**, **Casa Systems**, **Enea** and **Kaloom** for the network functions, **Palo Alto Networks** for security, **Red Hat** for automation and container orchestration (effectively replacing Nokia's virtualisation platform) and **Huawei** for 5G New Radio[3].
- Telenor has collaboration agreements with **AWS**, **Google Cloud** and **Microsoft Azure**, including exploring options for hosting VNFs/CNFs on the public cloud as part of MEC and IoT use cases.
- wgtwo, a multi-tenant cloud-native core platform whose main owners are Telenor and **Cisco** and delivered via AWS, completed end-to-end testing of its 5G SA core capabilities.

[2] Telenor Annual Report 2021
[3] https://www.telenor.com/media/newsroom/groundbreaking-5g-solution-paves-the-way-for-new-digital-services/

Telenor's telco cloud deployment accelerated in 2019 when it was getting ready for 5G rollouts in the Nordics



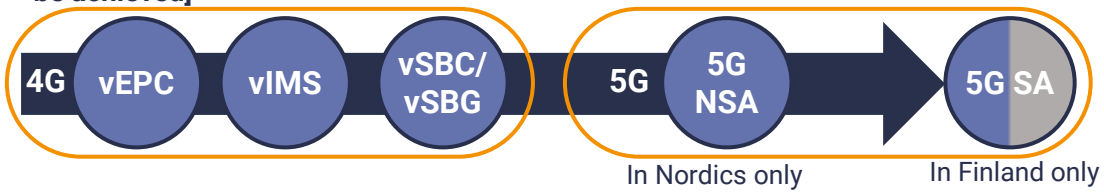
- Most of the public announcements concerning Telenor's telco cloud deployment have related to its core networks, in particular in 2019 when it was readying for 5G launches in its Nordic markets.
- The 2019 edge and access activity relate to cloud RAN in Pakistan using the Nokia Airscale Cloud RAN product. There have been no public announcement on commercial vRAN or open RAN deployments in Telenor's live networks. Since these types of deployment tend to be widely publicised by vendors or operators, this leads us to believe that Telenor is sticking with appliance-based RAN solutions, probably provided by Nokia or Ericsson, with some exceptions such as Huawei providing 5G NR in Denmark.
- The deployment in relation to the MANO platform and components concerns Telenor Pakistan and was to support its EPC.
- The two SD-WAN deployments relate to collaborations with Fortinet in Sweden and Finland for firewall and/or secure SD-WAN services.

For more details, check our interactive Telco Cloud Deployment Tracker

Core virtualisation journey and strategy

Committed to vendor diversity in the core

Examples of key core functions deployed by Telenor [grey represents stages yet to be achieved]



- Telenor has adopted a hybrid approach in its core strategy, building its cloud-platform and orchestration layers using proprietary Nokia components but deploying Ericsson and ZTE mobile core VNFs on top, alongside Nokia VNFs.
- This approach is unorthodox since it mixes elements which are usually integrated in a full-stack solution.
- Telenor has launched 5G NSA cores in all its European markets and is progressively switching to 5G SA: Finland in 2019 and Denmark planned in 2022.
- By using a vendor-neutral approach, despite strong links with traditional Scandinavian vendors Nokia and Ericsson, Telenor's core strategy has enabled it to maintain openness and guarantee vendor interoperability in order to deploy new and innovative use cases with relative ease.

RAN virtualisation journey and strategy

Telenor has no publicly known vRAN or open RAN deployments

Main RAN virtualisation steps by Telenor [grey represents stages yet to be achieved]

- Unlike other Tier 1 operators, Telenor has not been vocal about its endorsement or otherwise of open RAN. It does have a collaboration with Cisco exploring open RAN solutions (and other things, including cybersecurity) since the two companies renewed a pre-existing Joint Purpose Agreement in February 2019.[4]
- On a BEREC panel in 2021, Jimmy Ahlstrand – Chief Corporate Affairs Officer for Telenor Sweden – stated that he did "not think that open RAN could be a solution for Sweden in the short to medium term"[5] due to the country's tight security rules applicable to mobile networks. This did not, however, preclude Telenor as a group from looking into open RAN as part of its commitment to vendor diversity.
- Telenor Denmark uses Huawei's 5G NR for its 5G SA network, expected to be launched later this year. By contrast, no Huawei or ZTE equipment or software can be used in Sweden's 5G core and access networks following a regulatory ban issued by PTS in 2020 (and later upheld in court in 2021 and June 2022) on the ground of national security (see point made above by Jimmy Ahlstrand).

[4] https://tinyurl.com/3xc3az83
[5] https://tinyurl.com/y8etpe5a

Cloud infrastructure strategy

Using hyperscalers' tools; no plan to move core workloads to public cloud

In November 2021, framework agreement to explore the benefits of using Google Cloud (GC) tools and infrastructure for Telenor's, including developing / implementing NFs on GC to support 5G MEC

Telenor's Finish subsidiary DNA has relied on Affirmed Networks' (now owned by Microsoft) cloud-native 5G SA core.

In January 2022, deal to develop MEC and 5G connectivity services operated via AWS infrastructure and tools. Telenor uses CI / CD processes to develop and operate a programmable mobile core (based on that developed by wgtwo) supporting edge compute use cases developed by Telenor and third parties using AWS cloud and development tools.

Telenor co-provides the cloud platform (a hybrid of its own and AWS's) and the core on an as-a-Service basis to third parties. wgtwo uses a similar NaaS to support Telenor's Swedish MVNO Vimla.

Partnership map

Telenor's relationships show a varied vendor mix beside Nokia and Ericsson

MANO platform	NOKIA
Edge and access	NOKIA, HUAWEI, ERICSSON
Core	NOKIA, ZTE, affirmed, wgtwo, CISCO, ERICSSON
SD-WAN	FORTINET
Telco cloud infrastructure	NOKIA, Red Hat, Google Cloud, Azure, aws

- Despite having two behemoths, Nokia and Ericsson, on its doorsteps, Telenor has avoided total reliance on these two suppliers. It has successfully done so by not adopting full-stack end-to-end vendor solutions from any vendor. Its initial cloud platform, albeit supplied by Nokia, was modified to interoperate with other VNFs.
- Telenor has made extensive use of this ability by purchasing core VNFs from various suppliers: ZTE (Pakistan), Ericsson (Denmark, Norway, Sweden), Affirmed Networks (Finland). This flexibility has paid off, as demonstrated by its early launch of 5G SA in Finland and the imminent launch of a multi-vendor 5G SA core in Denmark.
- In Denmark, where the Nokia virtualisation platform seems to have been superseded by Red Hat's container-based orchestration platform OpenShift, it can be argued that Telenor has moved away from Pathway 1 to Pathway 2 (Red Hat being the overall integrator[6])

[6] https://www.fiercewireless.com/operators/telenor-uses-multi-vendors-for-its-open-source-5g-core

What Telenor has achieved so far

Technology

- From the start of its virtualisation journey, Telenor had a clear vision that working closely with preferred network vendors, in particular Nokia, should not preclude it from building open and interoperable networks which could (and did) evolve into true multi-vendor environments.
- This strategy has proved successful in its European markets where Telenor achieved a world-first (5G SA core in Finland in 2019) and will operate cloud-native container-based 5G SA mobile cores when these get launched (Denmark being the first in line).
- In APAC, where the emphasis remains on using 4G to continue growing connectivity revenues, the network evolution follows a more traditional Pathway 1 strategy with a stronger reliance on Nokia, in particular in Thailand and Bangladesh.

Organisation

- Telenor is actively engaged in a what it calls a "modernisation" path which means a strong focus on its 5G migration, shutting down its copper network (in its European footprint) and aiming for zero-touch networks through automation, thus leading to opex reduction. There has been staff reduction (22% between 2015–2019 and a further 15% anticipated for 2020–2022); however, even as virtualisation will have enabled Telenor automating its operations, it is unclear how much staff reduction can be linked to telco cloud.
- In the same period, Telenor also put a strong emphasis on staff upskilling: in 2018, employees were encouraged to undertake 40 hours of learning each year. In our report Building the learning telco, we identified Telenor as a champion of learning with a clear strategy and leadership commitment to promote internal knowledge, via a dedicated e-learning platform called 'Telenor U'.

STL Partners' assessment of Telenor's journey

Summary

- **We have classified Telenor as a Pathway 1 operator due to its reliance on Nokia products early in its virtualisation journey**: its telco cloud platform (MANO, NFVi, hardware), which Telenor deployed in all of its markets during 2018–20, and various core network elements (in Norway, Denmark and Sweden).

Benefits

- **However, Telenor avoided lock-in with Nokia** by ensuring that the vendor's telco cloud platform was adapted to interoperate with other vendors' cores: Ericsson in Norway, Denmark and Sweden, ZTE in Pakistan. DNA (acquired in 2019) came with its own core vendor, Affirmed Networks.
- **The collaboration with Nokia, coupled with a multi-vendor approach, has worked out well for Telenor**. It progressed rapidly through its 5G NSA core launches in the Nordics (all done by June 2019). Its Danish subsidiary is looking at launching 5G SA in a fully multi-vendor environment. DNA's acquisition in August 2019 did not derail the operator's plans for a 5G SA commercial launch later in the same year.
- **Another testimony to Telenor's multi-vendor approach is its collaboration with Cisco**: in 2017, the two formed JV wgtwo (now an independent company in which Telenor and Cisco still own most of the equity). This provides a multi-tenant, multi-G, cloud-native mobile core platform-as-a-Service. In addition and since 2018, Cisco and Telenor have had joint partnership agreements (JPAs) in various areas, from cybersecurity to open RAN[7].

Risks and concerns

- Apart from collaboration with Cisco, **we have not come across much evidence concerning Telenor's stance on open RAN at group level**. Given its preference for multi-vendor environments, and the evolution of the RAN towards disaggregation and open interfaces, it seems reasonable to think that should Telenor work closely with preferred vendors (say Nokia or Ericsson), it will want to purchase future-proof RAN solutions in order to mix and match vendors down the line.

[7] https://tinyurl.com/ms25ka2w

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Axiata: Vendor-supported best-of-breed approach driven by cost efficiency and digital services strategy

Pathway 2

Axiata is a Malaysia-based mobile operator with subsidiaries in six Asian markets: Malaysia (Celcom); Indonesia (XL); Sri Lanka (Dialog); Bangladesh (Robi); Cambodia (Smart); and Nepal (Ncell). The company also provides fibre broadband and converged services to consumers in Malaysia, along with a range of fixed and mobile services for enterprises in Malaysia, Indonesia and Sri Lanka. Consolidated group revenues in 2021 were USD5.8 billion, and the operator had 163 million mobile subscribers across all its markets by the end of that year.

We categorise Axiata as a Pathway 2 operator because it has pursued a pragmatic, multi-vendor approach to telco cloud, with deployments driven by the goals of cost reduction, capacity expansion and support for its growing digital services portfolio.

2015 — Early innovations in mobile core virtualisation

- Axiata carried out its first 4G core (EPC) virtualisation in Indonesia (2015): **Cisco** Virtualized Packet Core (VPC).
- This was replaced by **Huawei** CloudEdge (EPC) at the end of 2016.
- Axiata did not provide any public explanation for this change. However, the operator has a rigorous focus on cost and performance. So it is likely that the Huawei platform fulfilled its criteria more effectively at that time.
- Celcom deployed the same **Huawei** solution at the end of 2017.
- We understand that the EPC in Indonesia evolved to an innovative CUPS (Control and User Plane Separation) architecture, designed to support faster content delivery across Indonesia's dispersed geography.

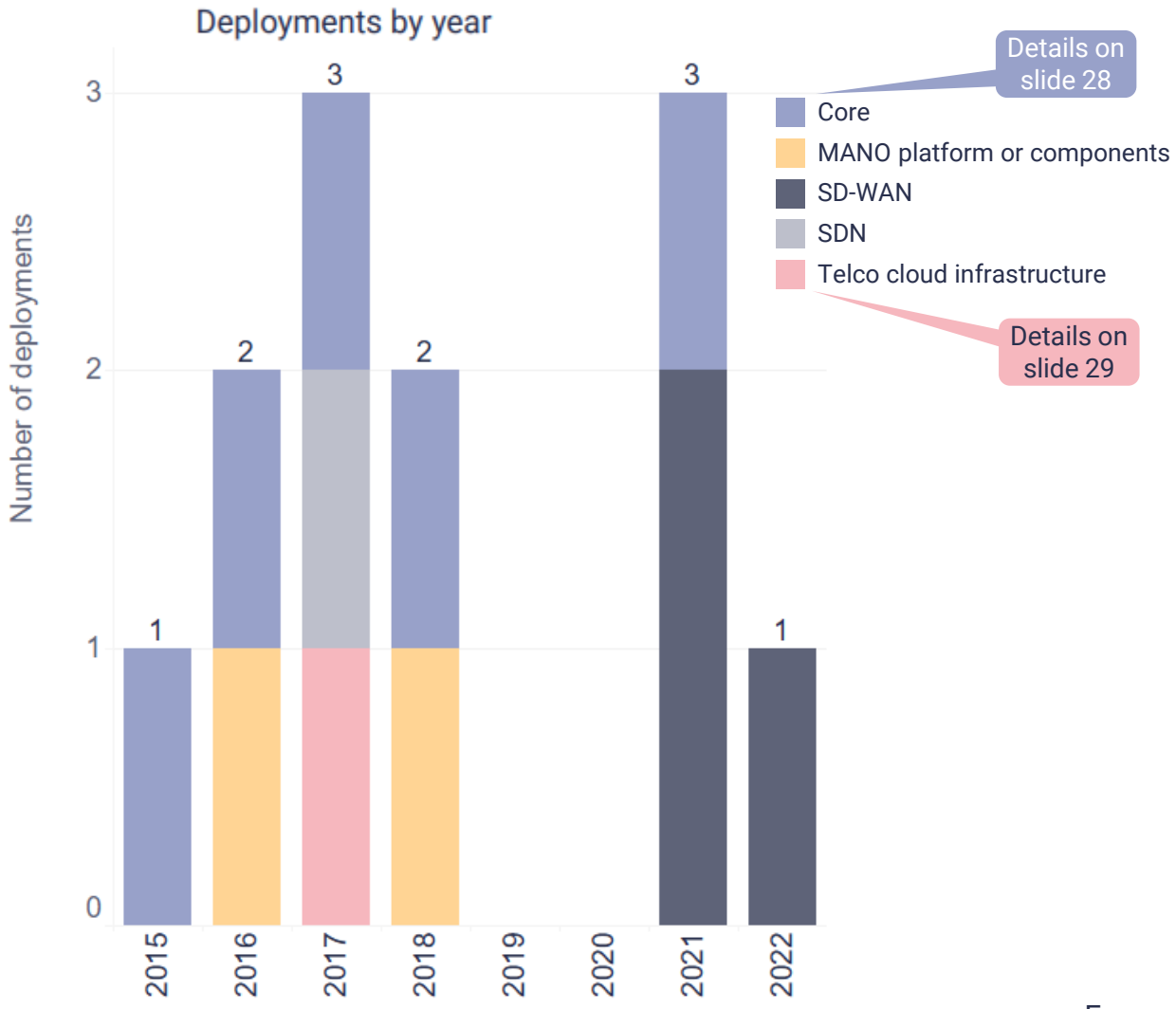
2016 — Exploring multiple options for the horizontal telco cloud

- In 2016, Axiata started to explore a number of different vendor solutions for its horizontal telco cloud.
- In 2016, XL deployed several **Ericsson** data centre hardware and NFV MANO components designed to support multi-vendor VNFs and virtualisation layers.
- The **Huawei** vEPC rolled out by XL in 2016 and Celcom in 2017 was, however, a full-stack solution that included Huawei's distribution of OpenStack and Huawei servers.
- Conversely, in 2017, XL also deployed **VMware** Cloud Solution as a virtualisation layer supporting some of its vEPC functions – thought to include the CUPS feature.
- The **Ericsson** NSA core deployed for XL's 5G launch in 2021 also included what was referred to as an NFVi from Ericsson, presumably OpenStack-based.

2021 — Ongoing work on mobile core and open RAN

- Indonesia is the only market where Axiata has launched 5G. Some service providers have launched 5G services in Malaysia. But these are delivered via a state-controlled wholesale network, DNB (i.e. not using the service providers' choice of vendors and platform).
- As of August 2022, **Celcom** had not introduced any 5G services. But the operator indicated it had completed its "5G core readiness upgrade" (migration to **5G NSA**) during 2021.
- Axiata's other markets are not yet sufficiently mature for 5G; 4G is still being rolled out and gaining new subscribers.
- To our knowledge, none of the EPCs in these markets has yet been virtualised.
- Axiata trialled **open RAN** in three markets in 2021: Malaysia, Indonesia and Sri Lanka. But no commercial launch of open RAN has ensued.

Multi-vendor core VNF deployments supported by multi-vendor virtualisation layers



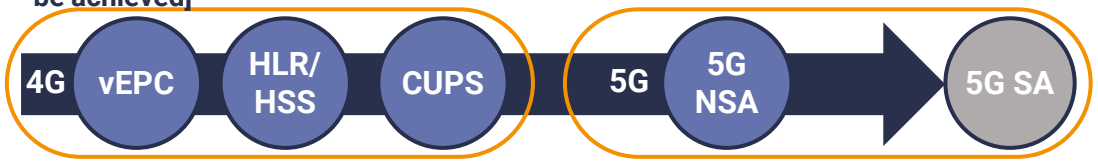
- Axiata's early telco cloud deployments related to its operations in Indonesia (XL), where it launched a vEPC from Cisco in 2015. This was retired and replaced with a full-stack solution from Huawei in 2016 (EPC, Huawei's proprietary distribution of OpenStack (FusionSphere) and Huawei hardware). The MANO deployment in 2016 comprised Ericsson software and hardware intended to support multi-vendor VNFs and virtualisation layers. A VMware virtualisation platform was added in 2017.
- The 2017 core deployment related to the Malaysian operations (Celcom) and replicated the Huawei deployment of 2016 in Indonesia (Huawei EPC and OpenStack, plus some Huawei servers).
- In 2018, XL adapted its Huawei vEPC to support CUPS. Nepali subsidiary Ncell also deployed a ZTE virtualised Subscriber Data Management (SDM) solution to support distributed service delivery.
- Having completed the first wave of mobile core virtualisations, there was a pause in deployments until XL launched a 5G NSA core provided by Ericsson as a full-stack solution (i.e. including a virtualisation layer).
- SD-WAN services were launched in 2021 and 2022 in Malaysia (Celcom) and Sri Lanka (Dialog), including a partnership with Fortinet.

For more details, check our interactive Telco Cloud Deployment Tracker

Core virtualisation journey and strategy

Pragmatic, multi-vendor approach

Examples of key core functions deployed by Axiata [grey represents stages yet to be achieved]



- Axiata has taken a multi-vendor approach to virtualising its mobile core:
  - Indonesian opco XL initially deployed a Cisco vEPC; but this was soon replaced by a Huawei solution, subsequently also deployed in Malaysia
  - XL deployed an Ericsson NSA core to support its 5G launch.
- The multi-vendor approach has extended to the cloud platforms supporting these VNFs:
  - Axiata adopted different horizontal telco cloud platforms (Ericsson and VMware) but also full-stack solutions where the VNF comes with its own OpenStack virtualisation layer (Huawei vEPC and Ericsson 5G NSA).
- This approach has been driven by two strategic priorities: cost-efficient expansion of capacity, and support for digital services:
  - E.g. we believe that the Cisco vEPC was replaced by Huawei because it better fulfilled Axiata's cost / throughput brief; but also because it could be adapted to a CUPS architecture supporting content delivery in remote areas.

RAN virtualisation journey and strategy

Open RAN to also support core business goals

Main RAN virtualisation steps by Axiata [grey represents stages yet to be achieved]

- Axiata has adopted the same pragmatic, multi-vendor approach to open RAN.
- In 2021, Axiata completed two trials of 2G and 4G open RAN across three markets: Indonesia, Malaysia and Sri Lanka. It selected open RAN vendors Mavenir and Parallel Wireless (PW) for the trials. These were vendor-supported best-of-breed projects, with Infosys acting as the SI. In addition, PW stated that its solution was deployed to Axiata's OpenStack cloud.
- The vendors in each trial reported that their platforms had achieved comparable or superior KPIs to the incumbent solutions in the same locations. Despite this, neither trial had resulted in a commercial deployment by the time of writing.
- Axiata has stated publicly that one of its main goals with open RAN is to drive down the cost of deploying and operating the RAN through supplier diversity and open innovation.
- Another key goal is to provide a cost-effective, scalable, programmable platform for Axiata- and third party-developed digital services and apps.
- It is also likely that one of the objectives of Axiata's open RAN trials in 2021 was to help ensure its existing, legacy RAN suppliers improved their offer.

Cloud infrastructure strategy

Private telco cloud as a vital underpinning of Axiata's digital services strategy

June 2020: deal to move 70% of XL's internal workloads (not NFs) to GC over three years. Deal included use of analytics and AI to enhance customer experience. In June 2021, extended to other markets.

Axiata uses Azure for various internal IT workloads but not for anything directly or indirectly customer-facing, such as NFs or BSS / OSS.

In 2021, XL established a Cloud Center of Excellence (CCoE) with AWS to migrate many internal applications, digital-service platforms and APIs to AWS. No network-facing functions have as yet been migrated.

- Axiata has not yet deployed or migrated any of its telco cloud platforms or VNFs to the public cloud. Developed over several years to enable a multi-vendor approach, Axiata's horizontal private telco cloud is regarded as a key strategic asset and is also a vital enabler of Axiata's digital services offerings.
- Axiata has demonstrated a willingness to combine and switch VNF and platform components from multiple partners in order to focus on cost and performance by:
  - Replacing one VNF supplier with an alternative one to better meet cost and performance stipulations (e.g. replacing Cisco by Huawei in 2016)
  - Playing suppliers off against each other to obtain competitive bids.
- For example, Axiata has used different modes of NFVi: as part of a single-vendor / full-stack deployment (with Huawei and Ericsson); with Ericsson, for a MANO and data centre hardware solution; with VMware; and with OpenStack in its open RAN trials.
- Axiata's ability to operate in a multi-vendor way ensures that it can make more stringent demands of its vendors around cost, performance and functionality.

Partnership map

Strong vendor and SI support for best-of-breed approach

MANO platform	ERICSSON
Edge and access	MAVENIR, Infosys, Parallel Wireless
Core	HUAWEI, CISCO, ERICSSON
SD-WAN	FORTINET, ngena
Telco cloud infrastructure	ERICSSON, HUAWEI, vmware, openstack.

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Open-source

What Axiata has achieved so far

Technology

- Axiata's telco cloud work to date has centred on deploying multi-vendor mobile core VNFs and telco cloud platforms in order to: reduce costs, improve performance, and enhance the programmability of its core connectivity and digital services.
- Axiata has not yet sought to create more advanced, vertical-specific use cases using CNFs, MEC and 5G SA functions such as network slicing. The virtualisation activity supports core connectivity and digital services, from which the operator is still generating growth.
- Within these limits, Axiata has been quite successful, and looks strongly positioned to continue rolling out profitable 4G and 5G services, including the potential use of open RAN.

Organisation

- Axiata's telco cloud activities have not had as profound an impact on its organisation as they have had at other telcos. This is partly because it is only at XL in Indonesia and Celcom in Malaysia where any significant volume of virtualisation has taken place, although Dialog Axiata in Sri Lanka has also introduced two SD-WAN products.
- Even where significant cloudification has occurred, it has not resulted in substantial business-model changes, since, as discussed above, the focus remains on generating growth from standard connectivity – particularly 4G – and the digital services that exploit it. Cloudification has enhanced Axiata's ability to mix and match vendors, which has supported its drive to reduce the cost to serve customers. It has stated publicly that cost per MB is its key metric.
- That said, particularly at XL, there has been a focus on recruiting and training staff with software and IT skills, driven by the company's digital services strategy and digitisation programmes. There was a 15% reduction in headcount at XL between 2016 and 2020; but this is more due to general efficiency and productivity measures than specifically telco cloud.

STL Partners' assessment of Axiata's journey

Summary

- **Axiata is an example of a well-executed Pathway 2 approach**, driven by specific business objectives: cost efficiencies, network performance, and support for digital services. Axiata has avoided succumbing to lock-in to any one vendor's virtualisation stack

Benefits

- **Axiata *has* deployed full-stack VNFs:** for example, Huawei vEPCs in Indonesia and Malaysia, and an Ericsson 5G NSA core in Indonesia. But it has shown it is willing to change suppliers so that cost and performance criteria are met, including through platform modifications (see slide 23).
- **Axiata has also demonstrated its readiness to adopt different models for its virtualisation layer**: Ericsson (horizontal layer or vertical stack: XL); Huawei (vertical stack: XL and Celcom); VMware (horizontal: XL); and OpenStack (XL, Celcom, Dialog). Its agility and multi-vendor approach puts Axiata in a strong position to negotiate the best price / performance deals.

Risks and concerns

- **Longer-term, we believe Axiata has gained the expertise to move into 5G SA core-enabled networks and open RAN**. But in order to maintain vendor-independence and maximise new value creation in the context of CNFs such as 5G SA and open RAN, Axiata will arguably need to develop further its own cloud skills and operating practices, such as DevOps and CI/CD.

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Turkcell: Establishing its best-of-breed telco cloud with bold vendor choices

Pathway 3

Turkcell is a converged telecommunications service provider in Turkey and the largest Turkish MNO. The company also operates in Ukraine (Lifecell), Belarus (Life) and Northern Cyprus. In 2021, Turkcell had total revenue of USD1.2bn and ca. 52m subscribers.

Turkcell fits our description of Pathway 3: DIY best-of-breed. It started building its telco cloud in 2017 with a goal to establish a horizontal telco cloud platform supporting multi-vendor deployments. Since then, as the approach started to mature, Turkcell has opted to widen its selection of partners across the different layers of the telco cloud stack as part of a move toward more cloud-native deployments.

2016: Following the vendor-supported BoB approach but with a twist

- Turkcell launched its Unified Telco Cloud initiative in 2019 and committed to virtualise 40% of its network by the end of that year.
- Turkcell embarked on its telco cloud journey with the intent of building a horizontal multi-vendor cloud (known as Unified Telco Cloud) but relying mainly on a single vendor (**Affirmed Networks**) as the main integrator. Relying on this challenger vendor was an innovative and more open approach compared to the typical telco choice favouring established, full-stack vendors such as Nokia or Ericsson.
- Unlike traditional vendors, Affirmed did not build the stack based on its own infrastructure. Instead, it relied on the **Red Hat** OpenStack platform. Affirmed supplied some critical network functions such as the Gi-LAN (first VNF to be deployed) and the EPC in addition to integrating functions from other vendors

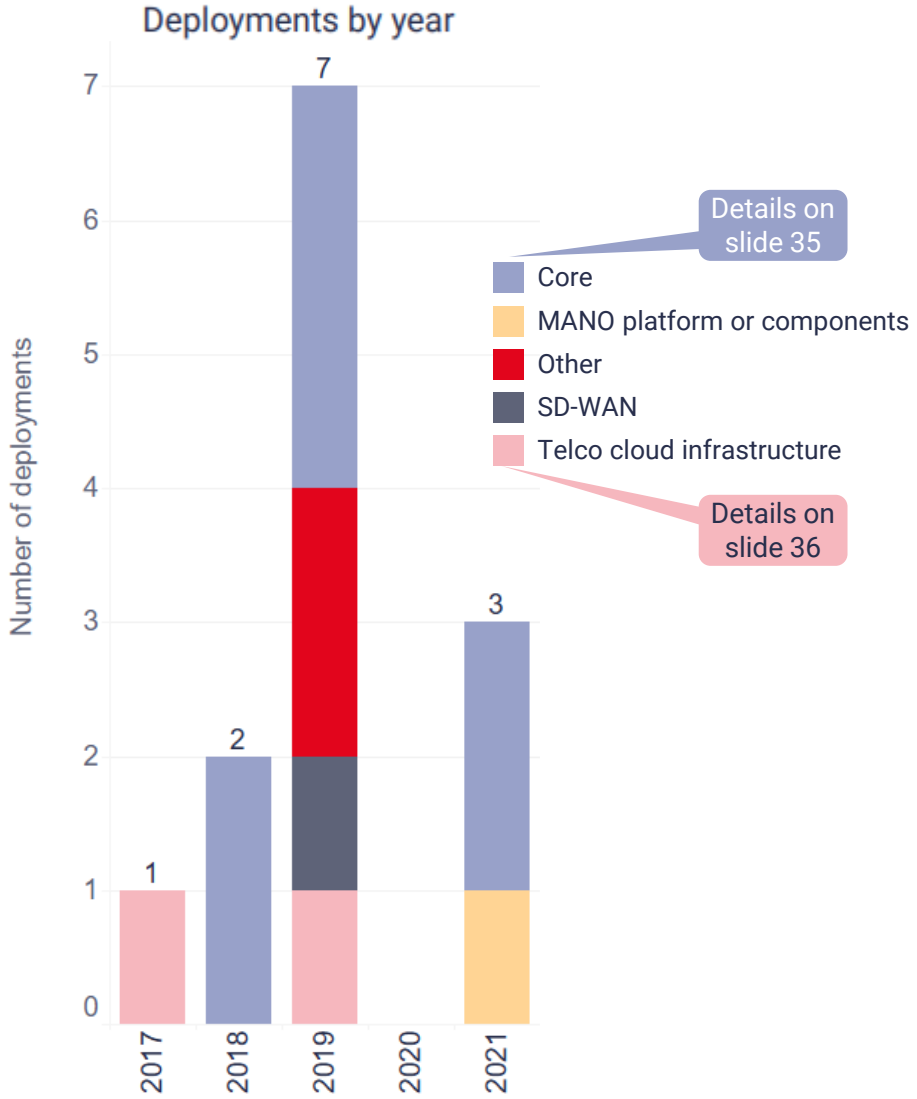
2019: Evolving its platform into a more open and multi-vendor cloud and accelerating the pace of VNF deployments

- Illustrating its best-of-breed approach, Turkcell deployed a **Huawei** vEPC ('CloudEPC') during 2019. This was in addition to its deployment of Affirmed's vEPC in 2018.
- The Huawei solution was deployed in part because it supported the - at that time - innovative CUPS standard. This was seen as a stepping stone to the more distributed architecture of the 5G core.
- It also continued to deploy multiple VNFs from different vendors (mostly undisclosed) over its cloud such as PCRF and NAT.

2020: Bringing innovation into the RAN and introducing cloud-native functions

- At this stage, Turkcell's journey started to mature with the telco taking more innovative steps in the RAN (see below) and transforming more clearly into a Pathway 3 telco.
- Turkcell became one of the early adopters of **open RAN**. It also deployed CNFs including an IMS from **Mavenir**, which was described as laying the ground for voice-over-5G (Vo5G).
- Following the Microsoft acquisition, Affirmed has continued in its system integration role for Turkcell's telco cloud. For example, in 2020-21, Turkcell deployed two Affirmed NFs (Domain and Service Orchestration, and Generic VNF Manager) designed to automate on-boarding, lifecycle management and orchestration of multi-vendor VNFs alongside legacy physical network functions.

Turkcell's telco cloud journey accelerated in 2019 when its open telco cloud platform became operational



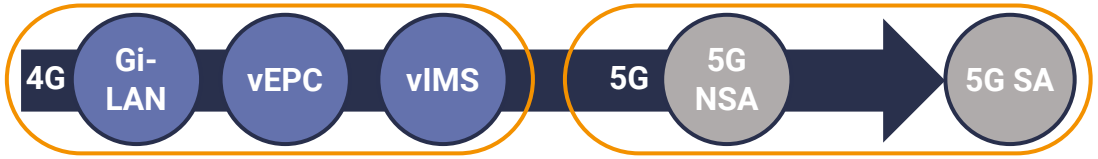
- The first two years of Turkcell's telco cloud journey saw the operator developing its horizontal telco cloud platform, with Affirmed Networks as the lead vendor and system integrator. Affirmed used its own distribution of Red Hat's virtualisation platform (OpenStack) and storage solution.
- After the OpenStack platform was launched in February 2019, Turkcell's deployments accelerated, with PCRF and NAT functions implemented in the same month (by A10 Networks for the latter), followed by SD-WAN from Versa Networks. Huawei's vEPC was launched in December of that year.
- During 2020–21 (with launches estimated to have taken place during 2021), Turkcell deployed Affirmed's Generic VNF Manager and Domain and Service Orchestration solutions to automate the on-boarding, lifecycle management and orchestration of VNFs deployed across multiple VIMs, alongside physical network functions. It also launched a virtualised WiFi gateway to enable Turkcell's 4G customers to connect seamlessly to trusted public WiFi networks.
- During the same period, Mavenir joined Turkcell's ecosystem of vendors, and Mavenir's cloud-native IMS was launched during 2021.

For more details, check our interactive Telco Cloud Deployment Tracker

Core virtualisation journey and strategy

Establishing an open multi-vendor platform through key partnerships

Examples of key core functions deployed by Turkcell [grey represents stages yet to be commercialised]



- From the beginning, Turkcell wanted to establish a vendor-agnostic platform that could scale rapidly and easily. It chose Affirmed's cloud native technology to help integrate multiple vendors on a horizontal telco cloud and avoid being lock-in in siloed stacks from traditional established vendors such as Nokia and Ericsson.
- As Turkcell became more mature and confident in the telco cloud space, it became increasingly open to collaborating with other established partners and integrating them within its unified structure.
- By February 2022, Turkcell announced over 75% of its core network was virtualised.
- Turkcell's role in its market as a digital service provider is a key factor in its network investment. For example, the operator selected the Gi-LAN as the first function to be virtualised to help maintain differentiation and ensure monetisation. This is because the Gi-LAN is a set of mobile core functions that sits between the mobile network and the Internet, and which enables particular value-added, digital services to take advantage of dedicated network resources, and to be managed and billed via the operator's OSS and BSS platforms.
- Turkcell's plans for 5G SA core are still evolving, with a potential 2023 launch. However, the operator states that its priorities are to understand the use cases unique to its market first and then build the network accordingly.

RAN virtualisation journey and strategy

Taking rapid steps to enabling RAN virtualisation

Main RAN virtualisation trials by Turkcell [grey represents stages yet to be commercialised]

- Turkcell started its RAN virtualisation efforts relatively early in its telco cloud journey and in parallel with its core activities.
- The operator continued its RAN virtualisation efforts and in 2020, it trialled cloud native and fully containerised open RAN with Mavenir as the first workload on its Edge Cloud which is the extension of Turkcell's horizontal telco cloud into edge locations. The deployment was based on standard O-RAN Split 7.2 architecture.
- Turkcell also trialled open RAN again in March 2022 with Remote Radio Units (RRUs) from Comba Telecom.
- Turkcell is clearly interested in open RAN and its multi-vendor characteristics, leveraging the capabilities of Turkcell's horizontal telco cloud. However, a clear strategy for the deployment of open RAN in the macro network has not yet emerged. When it does, it will be affected by the strategy for the 5G roll-out, including regulatory constraints around available spectrum, roll-out timelines, and security concerns. For example, there may be pressure to opt for a more homegrown, Turkish solution, as opposed to reliance on US open RAN vendors.

Cloud infrastructure strategy

Turkcell continues to rely on its private cloud

No telco cloud-related partnership

Turkcell does not have a direct partnership with Azure. However, it has a strong relationship with Affirmed Networks which is now part of Azure

No telco cloud-related partnership

- Turkcell has not yet leveraged any public cloud partnerships to support its telco cloud.
- This is in line with government policies around data sovereignty and protection that mandate users data to remain in the country. Also, none of major hyperscalers has a cloud PoP in Turkey.
- It is not yet clear whether Affirmed's acquisition by Microsoft will affect its relationship with Turkcell in any way. However, given the apparent exclusion of US hyperscalers, this might have some implications.

Partnership map

A diverse range of vendors across the stack supported by a single integrator

MANO platform	affirmed
Edge and access network	Comba, ERICSSON, MAVENIR
Core	affirmed, HUAWEI, MAVENIR
SD-WAN	VERSA NETWORKS
Telco cloud infrastructure	affirmed, odine solutions, Red Hat

STL PARTNERS

What Turkcell has achieved so far

Technology

- Turkcell has delivered a cloud-native telco cloud platform where the vast majority of its network functions are virtualised. This has resulted in shortening the innovation cycles for new VNFs/CNFs. This is also intended to support Turkcell's focus on digital services[8], by providing open, programmable networks over which application developers can deploy, operate and monetise their services.
- In relation to creating digital services, Turkcell wants to attract more partners to its platform and make it easy for them to onboard and innovate on top of it. The operator is aiming to achieve this via the open and scalable characteristics of its telco cloud.

Organisation

- The network virtualisation journey, along with Turkcell's aim to drive more automation and simplify its network, has been enabled by driving more synergies between the operations and the engineering teams.
- Turkcell trained its engineers on how to use its partners' technologies such as Red Hat OpenStack Platform. This resulted in network operations and engineering teams significantly upgrading their skills and expertise to be able to handle the operator's telco cloud migration.

[8] In 2020, Turkcell reported more than 27% of its revenue is from non traditional core telecoms services

STL Partners' assessment of Turkcell's journey

Summary

- **Turkcell is an example of how telcos can move through Pathways 2 to 3.** It started as a Pathway 2 telco relying on Affirmed to act as a system integrator before it transitioned to fully cloud-native Pathway 3 telco with more control over its platform and CNFs.

Benefits

- **Turkcell's decision to partner with a cloud-native challenger vendor at the beginning of its virtualisation journey** paid off by giving the operator the capacity to shape its platform according to its multi-vendor vision and accelerated its cloud native deployments.
- **The operator's adoption of fully cloud-native infrastructure and operations**; and its avoidance of vendor lock-in and tie-ups with US hyperscalers, might also reflect the operator's ambition to play a bigger role in the Turkish technology ecosystem as a whole.

Risks and concerns

- **The government's ambition to localise technology might impact Turkcell's partnership opportunities** as the homegrown vendor ecosystem including solution providers and cloud infrastructure providers is still developing

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AT&T: Combining in-house development and partnerships to optimise its cloud

Pathway 4

AT&T is one of the largest operators in the US, with total revenue of $169 billion and over 100 million subscribers in 2021. The telco was a pioneer and early adopter of NFV, having started its telco cloud journey in early-2014.

AT&T exemplifies Telco Cloud Pathway 4, which we describe as non-proprietary cloud-native. Like Pathway 3, Pathway 4 involves an evolution to, and adoption of cloud-native network functions, infrastructure, and operational processes. However, Pathway 4 operators take this evolution to the next level by abandoning exclusive ownership of the telco cloud platform and of the physical infrastructure that hosts it.

2014 – Becoming an NFV innovator with an ambitious vision

- The telco committed to virtualising **75%** of its critical network functions by 2020 to cut costs, enhance scalability and drive innovation.
- AT&T worked on defining its architecture to achieve this: Enhanced Control, Orchestration, Management, and Policy (**ECOMP).**
- In this phase, AT&T adopted a **proprietary** approach to telco cloud, though based on open-source technology like **OpenStack**.

2016 – Opening its platform to the developer community

- AT&T changed direction on ECOMP by opening it up to the **open-source** community.
- ECOMP subsequently merged with China Mobile's OPEN-O NFV architecture, and became the Open Network Automation Platform (**ONAP):** an industry-standard NFV Management and Orchestration (NFV MANO) platform that AT&T is still using in some of its networks.
- AT&T started rolling out enterprise CPE services

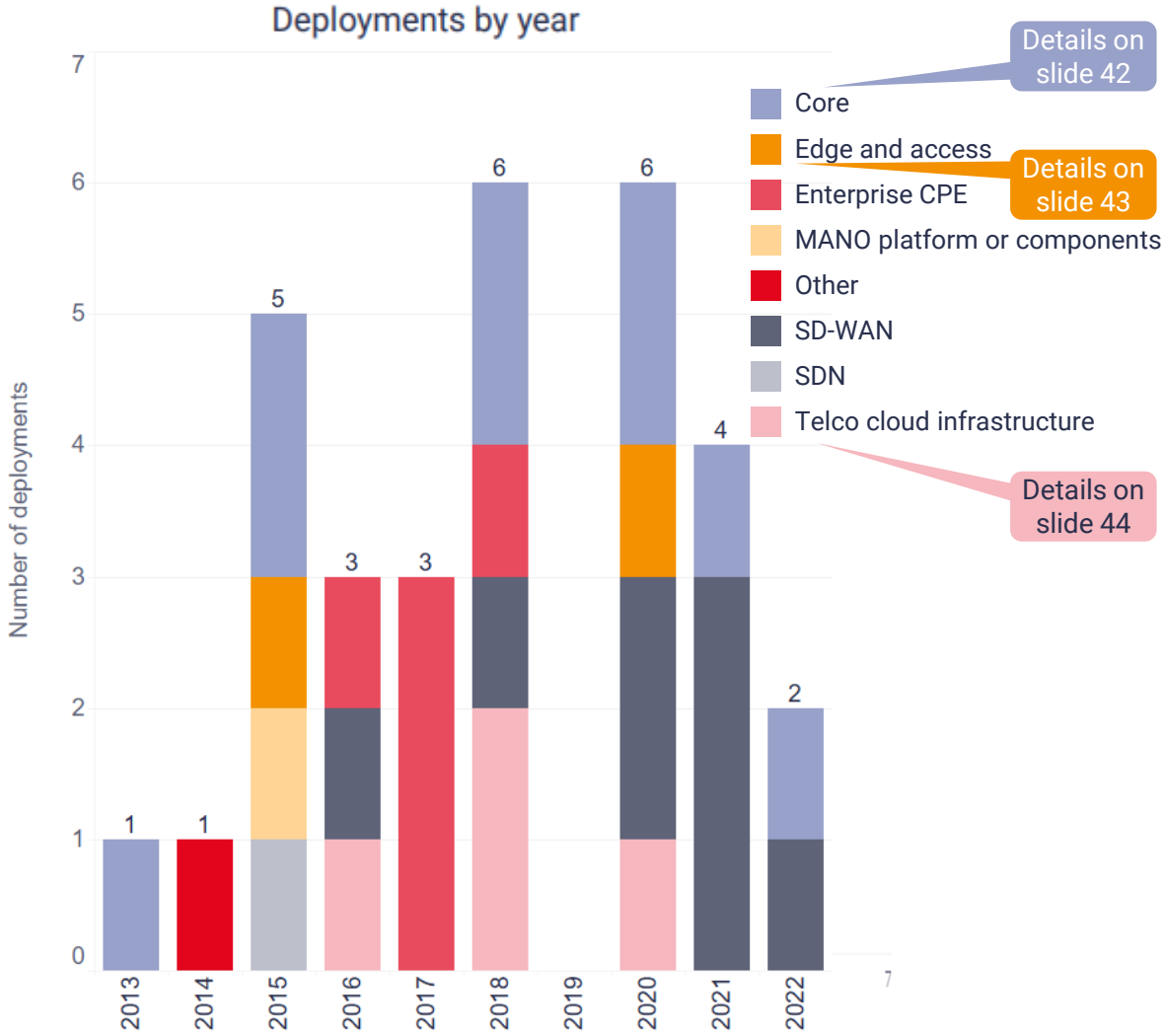
2018 – Building up its platform to meet virtualisation goals

- AT&T focused on developing its private telco cloud (**AT&T Integrated Cloud – AIC**) based on containerisation and hardware / software disaggregation. For example, in 2018, it created the 'Airship' project in partnership with SKT and Intel.
- It continued to progress towards its goal of 75% of network functions virtualised by 2020.
- AT&T also launched its 5G network and **NSA core**.
- Mostly from 2018 onwards, AT&T has also rolled out a succession of SD-WAN services from different vendors.

2021 – Strategic platform partnerships & focusing on developing V/CNFs

- Deal to transfer ownership and operation of the AIC (now known as Network Cloud) to **Microsoft Azure.** The rationale is that the platform will be developed and scaled more cost-effectively, while AT&T focuses on CNF development and new network-enabled use cases.
- AT&T maintains control over physical networking, and physical infrastructure operations and assets, including legacy telco technology platforms, core and RAN. It carried on the development and commercialisation of a portfolio of enterprise services leveraging VNFs and the ECOMP platform
- 5G SA core was still under development at the time of writing.

AT&T has announced more than 30 telco cloud deployments – and many more are not publicised



- The largest number of AT&T deployments over the years has been in the core domain (both mobile and transport). This reflects the operator's focus on its 2014 commitment to virtualise 75% of critical NFs by 2020. However, the very first deployment we logged for AT&T goes back to 2013: a vEPC to support GM's OnStar connected car service in Europe.
- The most significant deployments in 2015 were those of AT&T's ECOMP-branded MANO platform and two carrier SDN platforms: one self-developed as part of ECOMP, and one from Juniper. These deployments laid the foundation for what later became the AT&T Integrated Cloud (AIC) – later the Network Cloud that was sold to Azure.
- From 2016 to 2018, AT&T launched a wave of 'Network Functions on Demand' services (later re-branded 'Flexware on Demand'). These comprised managed, on-demand, multi-vendor, virtual enterprise CPE services, such as firewall, routing, and WAN optimisation. These were later in effect superseded by SD-WAN; and between 2016 and 2022, AT&T launched eight SD-WAN (and later SASE) services, from vendors Cisco, Fortinet, Palo Alto Networks and VMware.
- Core deployments in 2018-21 included two 5G NSA cores in the US and one in Mexico, and two IP core switching and routing platforms, including a disaggregated routing platform using network operating system and traffic engineering software from DriveNets . After the sale of the Network Cloud to Azure in mid-2021, AT&T development work is once again focused on the mobile core, with the 5G SA core expected to be launched by the end of 2022 (although it has been announced and then postponed before)

For more details, check our interactive Telco Cloud Deployment Tracker

Adopting a multi-vendor and open ecosystem, yet maintaining control over development

Examples of key core functions deployed by AT&T [grey represents stages yet to be achieved]

- AT&T has invested in virtualising its core more than any other part of its network. Over the years, it has virtualised its 4G core components and deployed a 5G NSA core. It is working on its 5G SA core and plans to start rolling it out commercially in late 2022.
- After claiming to have achieved the target of virtualising 75% of its network functions by 2020, AT&T shifted its strategy by selling its Network Cloud to Microsoft, meaning that its mobile core and other virtualised network workloads would now run on the Microsoft *Azure for Operators* – its branded, public telco cloud platform. The telco is prioritising the development of its SA core and plans to complete the migration of its Network Cloud to Azure by mid-2024.

- AT&T is retaining responsibility for developing, implementing, and operating its CNFs. The operator has not disclosed which vendor, or combination of vendors and its own internal development team, are supplying the 5G SA core. But it will be cloud-native and will offer the flexibility and scalability to support various 5G and MEC use cases.
- Prior to selling its Network Cloud to Microsoft, AT&T had partnered with Affirmed Networks (vEPC for connected car services) and Metaswitch (IMS and SBC).
- Now that AT&T's Network Cloud platform itself has been integrated within Azure for Operators, there are clearly many existing synergies between these partners and opportunities for further collaboration on core development going forward.

For more information, check our report Why and how to go telco cloud native: AT&T, DISH and Rakuten
For more information, check our report Microsoft, Affirmed and Metaswitch: What does it mean for telecoms?

RAN virtualisation journey and strategy

Gradual and careful steps into the RAN virtualisation as network complexity increases

Main RAN virtualisation steps by AT&T [grey represents stages yet to be achieved]

- As is the case with other US telcos, AT&T, has been racing to achieve nationwide 5G coverage as quickly as possible; so open RAN has not been as high-priority as it has been for the European Tier-1s, such as Deutsche Telekom, Telefonica and Vodafone.
- AT&T's main focus for virtualisation has been on mobile core functions up until the present day. AT&T realised that RAN virtualisation has its own challenges, since it is the most distributed and complex part of the network, with mission-critical requirements around performance and resilience.
- Nevertheless, in collaboration with other telcos, AT&T was a founder member of the O-RAN Alliance in 2018, designed to build industry-wide standards for RAN disaggregation and virtualisation.

Open RAN

- Although the telco has tested open RAN, it has not done much in its commercial network, with no major deployment announcements yet.
- AT&T's plan for open RAN is still not fully disclosed, the operator suggested that it would start to deploy it in in-building settings in 2022 before migrating gradually to the macro network, where the complexity increases.

Cloud RAN

- AT&T also announced in 2022 that it has been testing DU pooling, which is a form of cloud RAN, with Intel in order to improve RAN elasticity.
- AT&T plans to enable DU pooling across its network but has not yet committed to a timeframe. AT&T wants to make the technology open and available to other telcos as well.

Impact of MS Network Cloud acquisition

- One key factor in AT&T's RAN virtualisation journey is Microsoft's acquisition of AT&T's Network Cloud platform. This means that it is now also down to Microsoft Azure to develop the Network Cloud (as part of the Microsoft Azure for Operators portfolio), so that it acquires the capabilities needed to support open RAN for AT&T. Open RAN appears to be a broad strategic goal for the hyperscaler, but the timeline and the stepping stones are yet to be defined.
- The next steps in the platform evolution might involve:
  - Microsoft buying up an open RAN vendor
  - AT&T and Azure collaborating with other technology partners to build an open RAN platform with the resilience and performance required for the macro network.
- It is possible that this is less of a strategic priority for both AT&T and Azure than establishing the 5G SA core and support for private networking and MEC.

Public cloud & hyperscaler strategy

Collaborating with hyperscalers in a multi-cloud & hybrid strategy

No announced telco cloud-related partnership

Azure owns and operates the formerly private-AT&T Network Cloud platform. It also partnered with AT&T on the initial development of Azure Edge Zones (edge data centres that can be sited on the telco edge) prior to launching it as an Azure product.

Partnering on co-development of applications leveraging AT&T's own MEC platform and Network Edge (ANE) capabilities in 2021

- Over the years, AT&T has adopted more of an open-source approach across its stack. The telco is realising the importance of working through communities to tackle the complexities of network virtualisation.
- In March 2021, AT&T highlighted six open source initiatives that are key to its journey. AT&T is a key contributor to these initiatives and is already using some of the developed technologies in its stack as shown in chart. These are:
  - The Open Compute Project (OCP)
  - Airship
  - The Cloud Native Computing Foundation (CNCF)
  - The O-RAN Alliance
  - The Open Network Automation Platform (ONAP)
  - Anuket (aims to help telcos standardise cloud-native network functions)

Partnership map

Support from open-source technology and a range of vendors across the stack

MANO platform	ONAP, ECOMP
Edge and access network	BROCADE, intel, CISCO
Core	affirmed, DRIVENETS, Metaswitch Networks, ERICSSON
SD-WAN	CISCO, vmware, riverbed, paloalto NETWORKS, JUNIPER NETWORKS
Cloud and NFV infrastructure	ONAP, openstack, airship, Hewlett Packard Enterprise, CANONICAL, DANOS, MIRANTIS

Open-source

What AT&T has achieved so far

Technology

- AT&T has been a major innovator in the telco cloud space. As a trailblazer of our Pathway 3 model for telco cloud (DIY best-of-breed), AT&T built a cloud-native platform that was scalable and robust enough to be taken over by a hyperscaler.
- The extent of this achievement is demonstrated by Microsoft's acquisition of AT&T's Network Cloud and by the fact that many of the software and cloud specialists involved in developing it were transferred to Azure as part of the deal between the companies.
- By championing an open-source approach, AT&T has also been a major contributor to industry standards and initiatives, which further assisted the telco's overall virtualisation journey.

Organisation

- AT&T has taken steps towards software-centricity on both organisational and technological levels. In 2016, there was a significant drive to acquire, train and retrain staff with software skills. AT&T also acknowledges that becoming more software-centric has improved its agility and focus and allowed it to respond better to changes and demands on the network.
- As a result of the partnership with Microsoft, AT&T is restructuring its workforce and moving thousands of its highly skilled software engineers to Microsoft Azure. There have been a lot of redundancies from traditional roles as well: AT&T reduced its headcount by 17.5% between 2019 and 2021.
- AT&T is now focused on distributing the knowledge, systems and talents that it has developed throughout its virtualisation journey more broadly across the organisation and its areas of business.

STL Partners' assessment of AT&T's journey

Summary

- **AT&T started with ambitious plans and has ended up radically redefining its role as a telco.** AT&T has one of the most unique and bold cloud journeys. It started out by seeking to virtualise its network functions while retaining ownership and control over that network. However, by transferring ownership of those cloud elements to a hyperscale cloud provider, it has redefined its role and business model as a telco.

Benefits

- **AT&T is focusing on its role as a CNF and networking service developer.** AT&T has nonetheless retained a software-centric mindset and it is driving the development of its 5G core, RAN and other network functions to a large extent internally. It has refocused its organisation and operations around what it does best in the physical network, while also continuing to design and deploy software-based network functions.
- **The platform sale to Microsoft is an enabler of scale, not a write-down of an investment**. The Microsoft sale gives AT&T operational and financial agility – freeing it from the opex and capex burdens of developing and operating the Network Cloud. As a result, it can pursue other innovations for its 5G networks and its CNFs.
- **Now AT&T can benefit from scale, without all the cost of scaling**. In addition, AT&T's technology investments and use case development can in theory be done more cost-effectively by accessing and co-developing capabilities via Azure for Operators, of which it has already created much of the IP.

Risks and concerns

- **By selling its telco cloud platform to Micorosot Azure,** AT&T has freed its capacity to innovate in its core 5G networks and CNFS. However, there might be a risk that the operator will become reliant on Azure's innovation cycle and how it invest in the developing the platform moving forward

Questions? Get in touch

Reach out directly to the authors for any questions you may have

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