TOP 3 FACTORS DRIVING NETWORK CLOUDIFICATION

Whitepaper

TELCO & CONNECTIVITY

JUNIPER
RESEARCH

1.1 Introduction to Telecommunications Cloud

The shift towards telecommunications cloudification has been triggered by virtualising network functions; replacing traditional network appliances with efficient virtualised functions using industry-standard computing equipment. As a result, standardised server hardware can be used for multiple purposes instead of bespoke and proprietary hardware.

This introduction of virtualised network functions has enabled operators to deploy cloud business and cloud management practices for their network functions.

Juniper Research defines telecommunications cloud as:

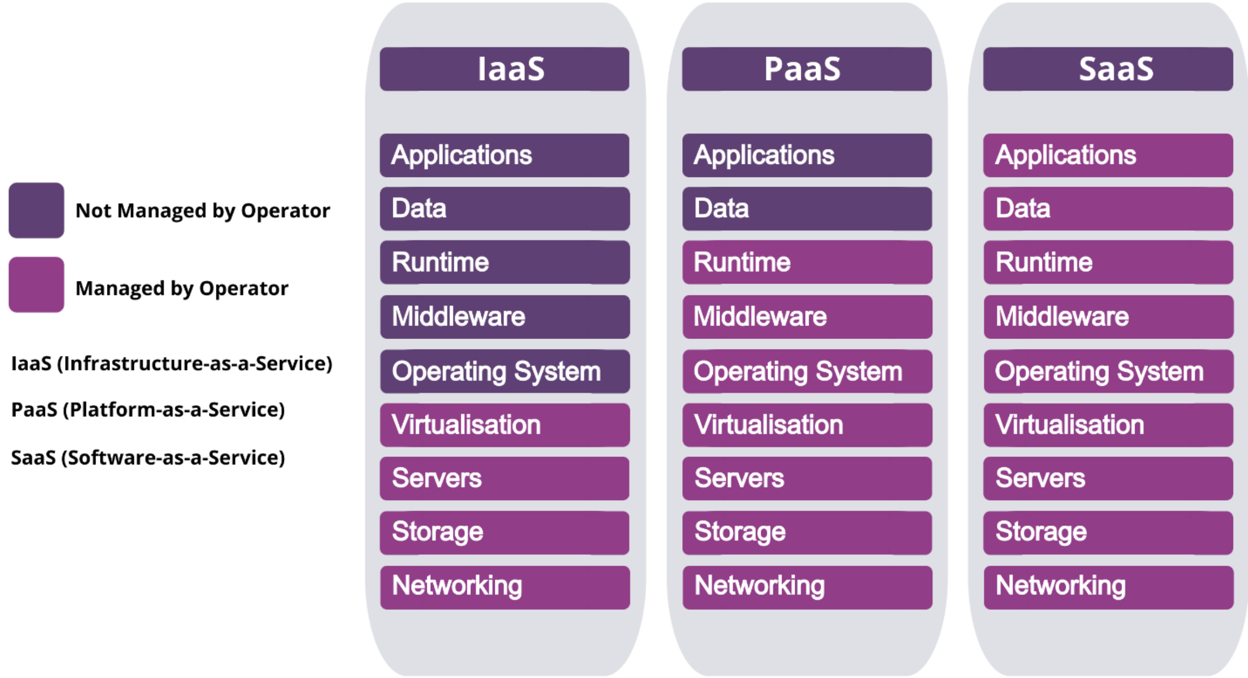
'The process of implementing cloud technology, services, and architecture into telecommunications networks.'

Moreover, operators have implemented cloud-native software such as containers into the design of virtualised network functions. These uses of cloud technologies in operator network functions form the basis of implementing cloud telecommunications.

1.2 Key Platforms and Services in Telecommunications Cloud

The three key platforms being leveraged by operators for cloud telecommunications are IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service), and SaaS (Software-as-a-Service).

Figure.1: IaaS, PaaS, and SaaS Management Responsibilities



Source: Juniper Research

1.2.1 IaaS

IaaS is a cloud computing model providing operators with access to computing resources such as virtual machines, servers, and virtualisation. Operators rent access to cloud infrastructure resources as individual services from a cloud service provider.

This gives cloud providers the responsibility for managing and maintaining cloud infrastructure, rather than operators; providing them with an alternative to constructing their own cloud infrastructure. As a result, through IaaS, operators can access low-cost cloud infrastructure, which they can rapidly scale with demand.

IaaS is used into telecommunications cloudification to provide the cloud resources necessary to run microservice containers for telecommunications services.

1.2.2 PaaS

PaaS is a cloud computing model where a third-party provider delivers hardware and software tools to users online. The PaaS provider hosts the hardware and software on its infrastructure; eliminating the need for operators to install in-house hardware and software on its infrastructure.

PaaS tools are used for application development, with the providers offering more of the application stack than IaaS. This includes middleware such as databases and other runtimes in the cloud environment.

1.2.3 SaaS

In SaaS, the cloud provider offers an entire application stack, with operators able to log in and use the application that runs completely on the provider's infrastructure. SaaS providers manage operators' application workload, and all the underlying IT resources. Operators are only required to control the data created by the SaaS platform.

Through SaaS, operators use vendors' off-the-shelf applications, minimising the time and resources they are required to commit to telecommunications cloudification. As software is delivered over cloud-based architecture, operators do not need to download upgrades or reinstall new versions of a product.

1.2.4 Key Open-source Projects in Telecommunications Cloud

This section will outline the key open-source projects influencing the telecommunications cloud market.

1.2.5 Kubernetes

kubernetes

Kubernetes is an open-source platform developed by the Linux foundation for automating deployment, scaling, and managing containerised applications. It coordinates a highly available cluster of computers connected to work as a single unit.

Kubernetes operates similarly to OpenStack, with various versions of the platform from key stakeholders in the telecommunications cloud market. These stakeholders include AWS (Amazon Web Services), Google, Red Hat, and VMware.

Despite these iterations, Kubernetes ensures that cloud-native network functions deployed can be delivered and distributed across multiple clouds, regardless of the version of Kubernetes being used. This enables cloud-native network functions to be efficiently distributed, orchestrated, and scaled across multiple locations and environments.

The features of Kubernetes include:

- Automated Roll-outs and Rollbacks – changes to an operator application or configuration are progressively rolled out, with Kubernetes also monitoring application health to ensure they do not all occur at once. If issues during the roll-out process arise, Kubernetes will roll back the change for operators.

- Service Discovery and Load Balancing – operators are not required to modify their application to use an unfamiliar service discovery mechanism. Instead, Kubernetes gives Pods their own IP addresses and single DNS name for a set of Pods, and can load balance across them.
- Storage Orchestration – operators can automatically mount the storage system of their choice, whether from local storage, a public cloud provider, or a network storage system such as iSCSI or NFS.
- Self-healing – containers are restarted when they fail, replaced, and rescheduled when nodes die, and killed when they do not respond to user-defined health checks. Containers are also not advertised to clients until they are ready to serve.
- Secret and Configuration Management – operators can deploy and update Secrets and application configuration without rebuilding their image and exposing Secrets in the stack configuration.
- Automatic Bin Packing – containers are automatically placed based on their resource requirements and other constraints without sacrificing availability. Operators can mix critical and best-effort workloads to increase utilisation and further save resources.
- Batch Execution – Kubernetes can manage batch and CI workloads; replacing containers that fail if desired.
- Horizontal Scaling – operators can scale their application up and down with a simple command, a UI (User Interface), or automatically based on CPU (Central Processing Unit) usage.
- IPv4/IPv6 Dual Stack – allocation of IPv4 and IPv6 addressed to Pods and Services.
- Feature Adding – features can be added to a Kubernetes cluster without changing upstream source code.

Container clusters in Kubernetes can support up to 300,000 containers, 150,000 Pods, and 5,000 nodes. Up to 110 Pods can be deployed per node. A Pod is a group of one or more containers, with shared storage and network resources, as well as a specification for how to run the containers. A node can be a virtual or physical machine which hosts the containers. Nodes are managed by a control plane and contain the services necessary to run Pods.

1.2.6 Metal^3

Metal^3 (Metal Kube) is an open-source project developed by the CNCF (Cloud Native Computing Foundation) which provides a set of tools for managing bare metal infrastructure using Kubernetes. These tools seek to provide a flexible solution for open-source bare metal provisioning which is easy to use and offers considerable automation.

The components of Metal^3 include:

- Cluster API Provider Metal^3 – enables the creation and management of physical servers using the Kubernetes Cluster API.
- Ironic – this is responsible for the provisioning of bare metal servers.
- Bare Metal Operator – automates the provisioning of bare metal servers using the open-source Ironic project.
- IP Address Manager – enables Metal^3 to provision bare metal servers with the necessary network configurations.

Metal^3 will act as an important foundation for new entries to the telecommunications cloud market, with new entrees able to utilise its advanced capabilities to improve network operations. This will increase the diversity of the solutions available in the market, reducing the risk of vendor lock-in when using software for bare metal.

Juniper Research recommends that operators ensure the management software can integrate data generated and collected from bare metal deployments into their wider network management systems. This will provide insight into bare metal cloud performance in the context of the entire network, allowing operators to further optimise their bare metal cloud usage and anticipate future return on investment.

1.2.7 Linux Nephio

NEPHIO

The cloud stacks used by operators are vertically siloed, meaning operators must manage the operating systems, container as a service platform, NIC (Network Interface Card) drivers, automation software, firmware deployment, updates, and usage for each cloud stack they deploy. This has dramatically increased the complexity of the cloudification process, leading to operators being unable to achieve the expected improvements in quality of service and efficiency from telecommunications deployments. Consequently, the development of advanced lifecycle automation and stack deployment automation solutions will be essential to developing future operator revenue strategies.

Nephio is an open-source project by the Linux Foundation launched in April 2022. It is a Kubernetes-based platform for the automation of network functions and their underlying infrastructure. Users can express high-level intent and access intelligent, declarative automation that can set up the cloud and edge infrastructure, render initial configurations for the network functions, and then deliver those configurations to the right clusters to get the network up and running.

Participating enterprises in Nephio include AARNA Networks, Airtel, Casa Systems, Deutsche Telekom, Ericsson, Google Cloud, Intel, Jio, Juniper Networks, Mavenir Systems, Nokia, Orange, Qualcomm, Rakuten Mobile, Red Hat, Ribbon Communications, Samsung, Tata Elxsi, Telefónica, Verizon, VMware, and Vodafone. In total, 61 enterprises contribute code.

The Nephio automation framework is built on the Google Open-Source projects kpt and ConfigSync and implements their configuration as data approach to configuration management. This enables operators to create, review and release configuration packages, which can then be cloned and customised to deploy network functions. Configurations packages are a collection of configuration templates for Linux Nephio.

This customisation can be fully automated or combine automated and human initiated changes without conflict and the loss of the ability to easily upgrade to new versions of the packages.

Therefore, through Nephio operators are able to accelerate the implementation of automation technology in managing their network functions, minimising operating costs and improving efficiency. Due to Nephio's existing market presence and the participation of major enterprises in the telecommunications space Juniper Research anticipates that Nephio will continue to play a key role in network function automation in the future. This is as the standardisation offered in the automation process will be critical to enabling operators to leverage multiple cloud stacks within a singular telecommunications cloud deployment. Moreover, Linux Nephio can act as a foundation for operators or telecommunications cloud vendors and hyperscalers to develop their own automation software, reducing research and development costs.

In February 2024, Linux announced Nephio R2 (Release 2). Included in Nephio R2 is a new SDK (Software Development Kit) which provides operators and vendors with the tools necessary to streamline interactions with the Nephio automation platform and quickly write K8 operators. It includes K8 custom resource definitions and libraries designed to enable K8 resource model functions. This allows operators and vendors write automation functions for the deployment and management of complex workloads, such as those within 5G networks.

Juniper Research recommends that operators begin to leverage this SDK to create custom automations for their 5G networks. These network functions require complex and precise distributed workloads which the SDK is ideal for. Through developing their own custom automations for 5G networks operators will be able to accelerate the deployment of cloud technology and cloud native network functions in their network. Moreover, operators will also be able to increase automation in their network management, improving efficiency and limiting operating expenditure.

A key area it is recommended that operators focus on developing through Nephio is network function autoscaling. Network function autoscaling enables operators to dynamically scale network functions to handle increase traffic or workload demands. This is achieved by dynamically scaling cloud compute resources provided to each network function. Through network function autoscaling, operators can create intelligent networks which alter their capacity in accordance with demand from consumers and enterprises; enabling operators to minimise network costs and improve efficiency.

1.3 Top 3 Trends Driving Telecommunications Cloud Adoption

Juniper Research anticipates that operators will spend $26.6 billion on telecommunications cloud in 2024, rising to $64.9 billion in 2028. The following trends will drive this increase:

- Total cost of ownership pressured by data consumption.
- New 5G deployments expand cloud opportunities in telecommunications.
- Sustainability goals, such as net zero, necessitate the cloud.

1.3.1 Total Cost of Ownership Increased by Consumer and Enterprise Data Consumption

Unlike in fixed wireless networks, the total cost of ownership in wireless cellular networks affected by the volume of data travelling over the network. This is as the radio access network is not dedicated to individual users, with network elements being allocated so that they are able to facilitate traffic generated by users. Therefore, increases in data over these networks rise operating costs and, thus, the total cost of ownership.

Juniper Research forecasts the total data generated over operator networks to increase from 1,929 EB in 2024 to 5,347 EB in 2028. The growth in total data is due to both increasing average data consumed per user, and a rise in the total number of users. Two key factors will drive this:

- The introduction of 5G networks has enabled consumers and enterprises to engage in more data-intensive activity on mobile networks without sacrificing latency.
- Consumer behaviour has changed to become more reliant on cellular data, with cellular connectivity becoming increasingly important to everyday life. As a result, consumers are more likely to use cellular networks than in previous years.

This 177% growth in the total data travelling over operator networks in the next four years will increasingly place pressure on the total cost of ownership for wireless cellular networks.

As a result, operators will increasingly invest in cost savings technologies to mitigate this threat to profit margins. Telecommunications Cloud will be one of the key technologies, with operators able to more precisely and efficiently distribute network resources, scaling back or up where necessary. This prevents unnecessary expenditure on operating costs such as energy, reducing the total cost of ownership.

Moreover, operators can limit the capital expenditure for the network infrastructure required to support these greater volumes of data. For example, cloud RAN is less than two thirds of the cost of distributed RAN.

This will further enable operators to restrict the impact of data consumption on the total cost of ownership for wireless cellular networks, with the virtualisation and pooling of BBUs (Base Band Units) offering considerable cost savings. The costs savings offered by telecommunications cloud deployments will enable operators to reduce basic expenditure on 5G network capital, thus enabling further innovation in new services and network quality. In turn, this will improve operator capacity to secure return on investment in 5G networks.

Juniper Research anticipates that cloud RAN in particular will be essential for operators moving forward, especially in 6G networks. 6G will utilise higher frequencies, increasing interference and limiting transmission length. For example, the longest transmission of 6G terahertz data as of April 2024 is just over 500 metres. Consequentially, Juniper Research anticipates the development of 6G RAN to be extremely complex and costly for operators, with vast numbers of base stations and small cells being required to provide comprehensive coverage.

1.3.2 New 5G Deployments Expand Cloud Opportunities in Telecommunications

As of 2023, there were 296 commercial 5G networks worldwide, with Juniper Research forecasting the total number of 5G connections to increase from 2.2 billion in 2024 to 5.9 billion in 2028. This represents a growth of 172% over the next four years.

The deployment of 5G networks will drive the adoption of cloud technologies in operator networks as its architecture increases the necessity and opportunity for cloudification.

The 5G architecture was defined in 3GPP (Third Generation Partnership Project) Release 15. The 5G system architecture is service based, meaning that viable architecture elements are defined as network functions that offer their services via interfaces of a common framework to any network functions that are permitted to make use of these provided services. This allows for greater virtualisation within operator networks, which can then be leveraged to further cloudify the network.

The service-based architecture is enabled by NRFs (Network Repository Functions) every network function can discover the services offered by other network functions. Network functions can then subscribe to and register for services from other network functions using HTTP.2 as a baseline communication protocol. This enables operators to more effectively manage their 5G core network and eliminate the need for network configuration every time a new network function is added to the network.

The 5G core also decouples the user plane from the control and user plane separation. The user plane carries network user traffic, whilst the control plane determines how data is forwarded. As a result, the 5G architecture allows the dynamic scaling of the control plane functions during periods of traffic peak. This is achieved without endangering user plane operations, granting operators greater control over their network operations. Operators can also dynamically scale their computing resources with network functions by operating network functions on cloud infrastructure, further improving network efficiency. In turn, this encourages the cloudification of operator networks.

1.3.3 Telecommunications Cloud Deployments Critical to Reaching Sustainability and Energy Efficiency Goals

In 2023, 39% of operators, representing 43% of global telecommunications revenue, had committed to net zero. Operators such as Telefónica, and T-Mobile have also agreed to have their net zero targets reviewed and verified against the new Net Zero Corporate Standard, and operators now purchase 24% of their electricity directly from renewable resources.

As part of these sustainability goals, operators have made the development of energy efficiency a significant focus, with energy expenses ranging from 15% to 40% of total operator operating expenditure and 2% to 3% of global energy consumption. According to the GSMA, 92% of operators place sustainability and energy efficiency as a leading focus of their network transformation strategy. Consequentially, these goals will receive significant investment over the next four years.

Virtualisation has been a critical component of these strategies, as through capabilities such as capacity aggregation operators can significantly improve the energy efficiency of network operations. This has enabled operators to cut energy consumption and carbon emissions over the last few years.

However, despite improvements in energy efficiency, the telecommunications industry continued to account for 2%-3% of global energy consumption in 2023, and energy consumption is expected to remain in this range in 2024.

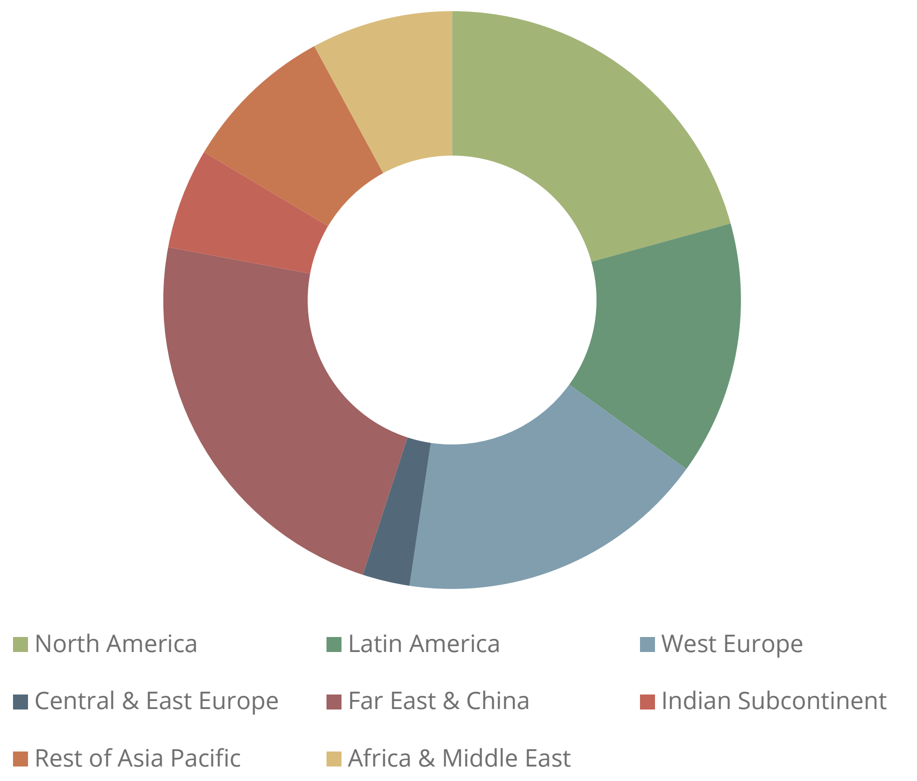
To further pursue their sustainability goals and increase energy efficiency, operators must expand the ways in which they leverage their telecommunication cloud deployments to improve energy efficiency. A key area operators must focus on is the Kubernetes Power Management Operator, which offers power management and energy optimisation capabilities for Kubernetes nodes. Operators must leverage these capabilities to turn off idle CPU cores, which are unnecessary for current workloads. Operators can also reduce CPU frequency to lower power consumption. This will enable operators to dynamically adjust the power consumption of their cloud infrastructure, thus increasing energy efficiency.

1.4 Market Forecast Summary: Total Telecommunication Cloud Expenditure in 2028

Operators will invest $26 billion in cloud services in 2024, with expenditure growing to $65 billion in 2028. To maximise the impact of this investment in telecommunications cloud operators must leverage the cloud's centralisation to develop automated network management.

- The growth in 5G network usage over the next four years will result in a corresponding 110% growth in cellular data over the next four years. This growth in cellular data will be driven by the rising adoption of data intensive IoT use cases, such as automated manufacturing and vehicle infotainment systems.
- To manage this substantial growth in cellular data, operators must leverage cloud-based network management systems to automate the management of network resources in real-time and at a local level. Critical to this automation will be machine learning, which will enable real-time traffic analysis, enabling automatic changes to network resources in response to unexpected traffic patterns. This will prevent congestion from sudden increases in cellular data on operator networks, protecting quality of service.
- Additionally, investment in cloud technologies will be instrumental in enabling operators to achieve sustainability targets. Operators will use machine learning to automate network management, reducing power to network elements when user demand is low. However, operators must also insulate mission-critical traffic when reducing power, to guarantee quality of service for enterprises.

Figure 2: Total Operating Expenditure on Telecommunications Cloud ($65 Billion), Split by 8 Key Regions, 2028



Source: Juniper Research

Order the Full Research

Discover an invaluable analysis of how operators can successfully deploy cloud technology into their cellular networks (wireless) in this brand-new report. Featuring an extensive investigation of key operators' cloudification approaches such as from Turkcell, Bharti Airtel and Verizon, the report delivers actionable insights into the development of innovative technologies in the telco cloud such as MEC (Multi-access Edge Computing) and C-RAN (Centralised RAN), with data split across 60 countries, plus the latest information on Linux Nephio and strategic recommendations for its use.

Key Features

- **Market Dynamics:** Insights into key trends and market expansion challenges; addressing issues posed by the highly complex nature of telecommunications cloud. Analysis and recommendations on how operators can gain a competitive edge in customer satisfaction through improved quality of service through leveraging advanced cloud computing technologies, such as public cloud services.
- **Key Takeaways & Strategic Recommendations:** In-depth analysis of key development opportunities and findings within the telecommunications cloud market, accompanied by strategic recommendations for operators and cloud service providers.
- **Benchmark Industry Forecasts:** The business overview into operators, telecommunications cloud service providers, and hyperscalers provides forecasts for the total number of active mobile subscribers, and operator revenue from mobile subscribers. Also features forecasts for total telecommunications cloud expenditure split by public and private cloud technologies, and cellular data serviced by the cloud.
- **Juniper Research Competitor Leaderboard**: Key player capability and capacity assessment for 11 telecommunications cloud service providers via the Juniper Research Competitor Leaderboard. This features market sizing for major players in the telecommunications cloud industry and detailed analysis of their respective telco clouds.

What's in this Research?

1. **Market Trends & Strategies:** Detailed analysis and strategic recommendations for telecommunications market, including analysis of key technologies and use cases, such as cloud RAN, open-source projects, and MEC.
2. **Competitor Leaderboard:** In-depth analysis of 11 vendors' capabilities, via the Juniper Research Competitor Leaderboard (PDF).
3. **Data & Forecasts:** The forecast suite features forecasts for the total number of mobile subscribers, operator revenue from mobile subscribers, telecommunications cloud expenditure, total cellular data generated, and total cellular data serviced by the cloud.
4. **Interactive Forecast Excel:** Highly granular dataset comprising over 11,000 datapoints; allied to an interactive scenario tool, giving users the ability to manipulate Juniper Research's data.
5. ***harvest* Digital Markets Intelligence Centre:** 12 months' access to all the data in our online data platform, including continuous data updates and exportable charts, tables, and graphs (ONLINE).

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