WHITE PAPER

Overview of Orchestration

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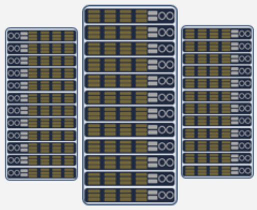
Telcom Industry’s Move to Cloud-Native Designs

Telecom networks consist of hundreds of complex systems across a variety of technologies, e.g., access, transport, core, radio, OSS, BSS etc. There are many Telecoms Equipment Manufacturers, aka OEMs, who specialise in building these complex systems. Traditionally, these systems were designed to run on proprietary and specialised hardware. OEM vendor generally provides a complete solution consisting of many complex systems, e.g., 4G Core from a vendor composed of Mobility Management Entity (MME), Serving Gateway (SGW), Packet Data Network Gateway (PGW) and Home Subscriber Server (HSS) systems.

These systems run on physical servers and can be referred to as **Physical Network Functions (PNF)**. While this approach enabled OEMs to innovate and build complex systems, it comes with its own challenges for Communication Service Providers (CSPs). The hardware needed to run a system is proprietary and expensive. CAPEX is high for CSPs to set up a new data centre or expand capacity in existing data centres. It also increases dependency on a particular vendor and results in vendor lock-in. To roll out a new service or technology, CSPs would need months to set up the data centre, upgrade necessary systems and prepare the network. This leads to customer attrition and revenue loss.

Physical Network Functions (PNF)

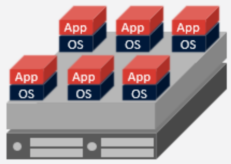


- Proprietary and Costly Hardware
- Regional Data Centers
- Vendor Lock-in
- Longer lead time for expansion and service rollouts

The launch of cloud computing services more than a decade ago revolutionised the way we think about infrastructure. Virtualisation and Virtual Machines paved the way for many IT companies to redesign their systems to run on the cloud. It is now possible to create a Virtual Machine (VM) of the desired configuration in minutes and run any workload or system. Cloud computing provided elasticity and agility to enterprises and enabled them to deliver world-class services to their customers.

The Telecom Industry started its own Digital Transformation journey a decade ago. The main goal of Digital Transformation is to modularise and abstract software components and services to make them more flexible and interoperable.

Virtual Network Functions (VNF)

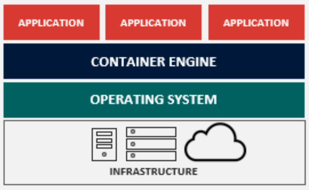


- COTS Hardware
- Distributed Data Centers
- Elasticity, Shorter Lead Times for service rollouts
- Still hard to manage and maintain

In the first phase of Digital Transformation, OEMs redesigned their systems to work on Virtual Machines running on commodity COTS hardware. These systems run on virtual servers and can be referred to as **Virtual Network Functions (VNF).** This was a significant advantage to CSPs as cloud computing can be leveraged to reduce lead time for rolling out new services. This enabled CSPs to create new revenue streams and roll out new services faster. CSPs could scale up and create new VMs in minutes during peak load and scale down when the load on the system reduces. However, VNFs were still as monolithic as PNFs and in some cases offering less performance.

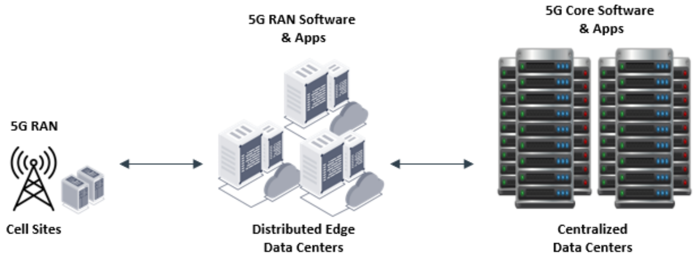
With advancements in virtualisation and container technology, the second phase of Digital Transformation focused on redesigning systems to work on containerised systems. These systems run on containers and can be referred to as **Cloud Native Network Functions (CNF).** CNFs and more aligned to Service Based Architecture (SBA) which allows to design and run distributed applications and systems. To run an application in containers, it needs to be designed and built using microservices. An application may consist of many microservices running in multiple containers in a cluster built on COTS hardware. Containers provide greater flexibility and agility for CSPs, giving better control over operations.

Cloud Native Network Functions (CNF)



- COTS Hardware
- Efficiency Network Operations
- Agility, Elasticity, On-Demand service rollouts
- Microservices

With Open RAN (O-RAN) initiative focused on transforming Radio Access Networks (RAN) towards open, intelligent, virtualised, and fully interoperable, RAN is distributed into many virtualised and standardised systems. While a core network can be deployed and managed in few large regional data centres, virtualised radio network would need many distributed edge data centres to deploy and manage RAN (Radio Access Network). Typically, a Tier 1 CSP is expected to run tens of large, centralised data centres and thousands of distributed edge data centres of varying sizes.



While Digital Transformation and Cloudification of Telecom Networks have benefited CSPs, it also comes with new challenges, e.g., managing thousands of data centres, rolling out new services in minutes, scaling up/down services in seconds, detecting, and fixing a fault in seconds etc. CSPs need new tools to deploy, manage and operate Cloud Native Telecom Networks.

The Need for Orchestration

Orchestration is not new to Telecom industry. For years, OEMs and CSPs have been building solutions in OSS/BSS area for automating workflows. Focus for these solutions has been mainly on automating user or business workflows. Since these solutions were deployed on PNFs, there were not many solutions available for automating lifecycle management of PNFs itself.

Digital Transformation brought a foundation to Network Function Virtualisation (NFV) – an idea to move network functions from dedicated hardware appliances to software-based virtual machines or containers, which can run on standard computing hardware. NFV opens possibilities to deploy, scale and manage network functions in real time. Network functions are transformed from dedicated hardware to software-based virtual machines (VNFs) or cloud-native container-based CNFs (Cloud Native Network Functions). They can be dynamically created, configured, deployed, and optimised for different environments, including public clouds.

Existing tools and processes are insufficient to manage and operate complex Telecom Networks built on VNFs/CNFs. A new set of tools and techniques are needed to automate the creation and management of Telecom Networks and services. CSPs face many challenges in deploying and operating Telecom Networks while maintaining a competitive edge and creating new revenue streams. Some of the challenges are:

- Manage several distributed data centres, including physical hardware, virtual hardware, and software.
- Increasing network scale, bandwidth, and flexibility.
- Reduce operational costs and deploy services faster – in minutes rather than weeks or months.
- Manage complex networks and services with equipment from multiple vendors.
- Network Functions deployed across Private / Public / Hybrid clouds.
- Time to market and variety of products and services offered.

Addressing these challenges has resulted in developments in open-source projects and in OEMs solution offerings that focus on simplifying operations and management of networks. These solutions are focused on automating activities ranging from the configuration of physical servers and creating virtual resources to creating end-to-end network services. These automation tasks need to run autonomously and orchestrate/coordinate actions across multiple systems. This has resulted in the large-scale development of Orchestration solutions from leading vendors and open-source communities.

What is Orchestration?

> *"Orchestration is the automated provisioning, configuration, management, and coordination of computer systems, applications, and services."*

It is a hierarchical architecture that serves to coordinate and manage systems which span across multiple cloud vendors and domains. As networks move from homogeneous, monolithic, and siloed domains to heterogeneous, cross-domain, multi-vendor networks, the need for orchestration becomes essential for the cost-effective and efficient management of networks and services.

With the evolution to 5G and O-RAN, Telecom networks are no longer static. Networks are dynamic and need to be automated to offer tailored, customisable, and on-demand services in minutes with the ability to change the quality of service according to changing customer demands.

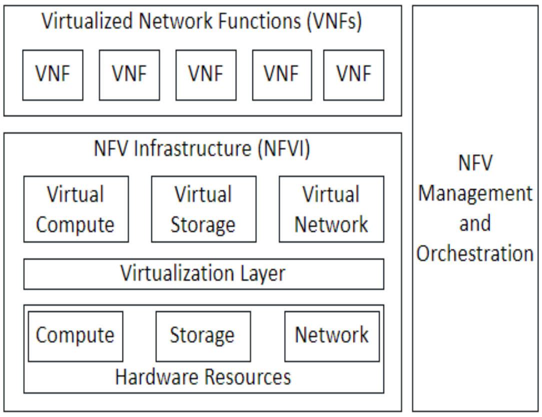
Orchestration is the key to reducing operations costs, delivering next-generation customer services, and enabling new revenue streams for CSPs.

Orchestration Standards

The **European Telecommunications Standards Institute (ETSI)** is an independent, not-for-profit, standardisation organisation in the telecommunications industry. Over the years, ETSI has defined standards and regulations for Network Function Virtualisation (NFV) and **Management and Orchestration (MANO)** framework.

ETSI MANO NFV Framework and Reference Architecture have been adapted by most of the Orchestration solutions available in the market today (either open-source or vendor developed).

The ETSI NFV ISG Architectural Framework (ETSI GS NFV 002) standardises NFV by defining the various elements required in virtualising networking functions. This framework contains two main sections - the **High-Level NFV Framework** and the **Reference Architectural Framework.**



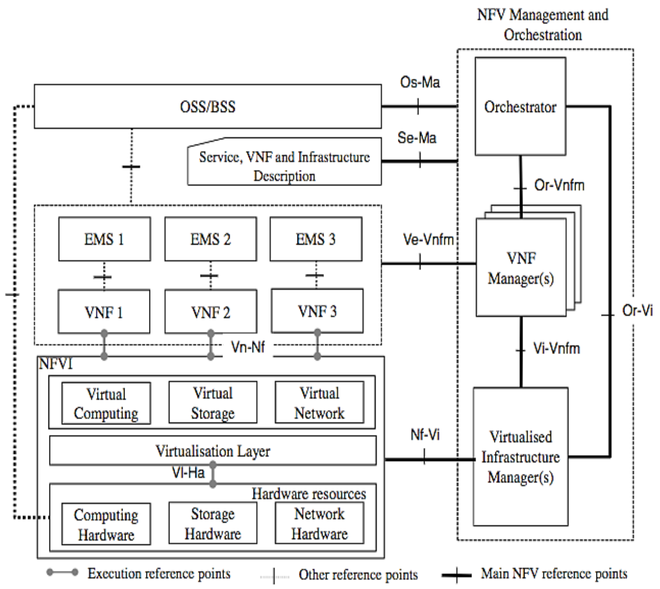
High-Level NFV Framework - This framework describes, at an elevated level, the implementation of Network Functions on physical and virtual infrastructure. This is based on three NFV working domains:

NFVI (NFV Infrastructure) – A set of resources (physical or virtual) used to host and connect VNFs/CNFs, such as computing, storage, or networking.

VNF (Virtual Network Function) – A software implementation of a network function capable of running on top of the NFVI.

NFV Management and Orchestration (MANO) - Covers the management and orchestration necessary for provisioning VNFs and their life cycle management.

NFV Reference Architectural Framework - This framework extends the previously mentioned High-Level NFV Framework. It defines functional blocks in MANO and their interactions over standard APIs (application programming interfaces). NFV MANO is divided into 3 functional blocks:

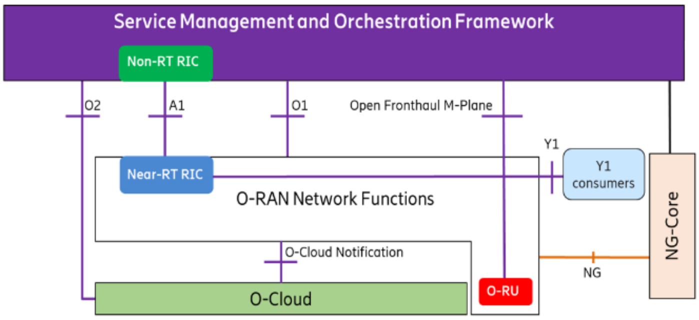


Virtualised Infrastructure Manager (VIM) – Controls and manages the NFVI (Network Function Virtualisation Infrastructure), such as the virtual/physical compute storage and networking resources.

VNF Manager (VNFM) – Responsible for the life cycle of VNFs/CNFs, such as the creation and termination, along with the FCAPS (Fault, Configuration, Accounting, Performance and Security Management).

NFV Orchestrator (NFVO) – Responsible for management of Network Services (NS) and VNF packages, lifecycle management of NS and performs validation/authorisation of MFVI requests.

For virtualised RAN, O-RAN alliance has defined standards and specifications for Cloud Infrastructure, Virtual RAN Network Functions, and functional blocks for the management of infrastructure and network functions. O-RAN high-level architecture defines below logical components.



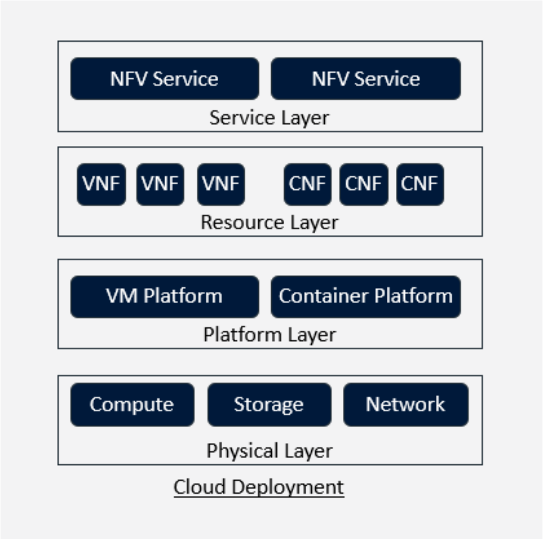
O-Cloud – This is the NFVI used to host VNFs/CNFs RAN Network Functions.

O-RAN Network Functions – Consists of RAN Network Functions O-CU, O-DU, O-RU and Near-Real Time RAN Intelligent Controller (RIC).

Service Management and Orchestration Framework (SMO) – SMO provides management and orchestration capabilities for managing O-Cloud and O-RAN Network Functions. SMO also includes Non-Real Time RIC for AI/ML workflow, including model training and hosting applications designed to run on Non-Real Time RIC (rApps).

Orchestration Taxonomy

Any Telecom Network service based on VNFs/CNFs (e.g., 5G Core or Enhanced Mobile Broadband (eMBB) slice) can be mapped to four layers:



Physical Layer – This layer consists of physical servers providing computing, storage, and networking.

Platform Layer – This layer consists of virtualisation runtime (for VNFs) or container runtime (for CNFs). This layer provides virtual computing, storage, and networking.

Resource Layer – This layer consists of Virtual Network Functions (VNFs) or Cloud Native Network Functions (CNFs) providing specific functionality. A VNF may consist of multiple VMs, and a CNF may consist of multiple microservices.

Service Layer – This layer consists of logical service (e.g., eMBB slice), which consists of multiple VNFs/CNFs.

Each layer may have solutions from different vendors integrating with each other over standard interfaces. Since a CSP would need to manage hardware and software resources spread across thousands of distributed data centres, there is a need to have an Orchestrator for each layer performing specific functions.

Hardware Orchestrator	Platform Orchestrator	Resource Orchestrator	Service Orchestrator
Provides configuration and management of bare metal servers with computing, storage and networking, Automated OS patching, security patching etc.	Provides configuration and management of runtime environments to run VNF or CNF workloads, Creation of VMs, Virtual Networks, K8S clusters etc.	Provides configuration and life cycle management of VNF or CNF resources across multiple domains (RAN, Core, Transport etc.) deployed on edge and regional data centers.	Provides configuration and management of NFV services (e.g., virtual 5G core, eMBB slice etc.)

Orchestration Solution Landscape

Any Telecom Network service based on VNFs/CNFs (e.g., 5G Core or Enhanced Mobile Broadband (eMBB) slice) can be mapped to four layers:

We discussed different types of Orchestrators needed to manage virtual Telecom Networks. There are many solutions available today fulfilling needs at different Orchestration layers. Some of these are solutions implementing NFV use cases and providing out-of-the-box support for managing VNFs/CNFs, while some are frameworks which can be used to prepare bespoke solutions. Following is a list of some of the leading solutions (both open-source and vendor-developed) available today for each layer.

Hardware Orchestrator	Platform Orchestrator	Resource Orchestrator	Service Orchestrator
Dell Bare Metal Orchestrator (BMO), Open Distributed Infrastructure Management (ODIM), Ansible, Terraform, Chef, Puppet.	OpenStack, Redhat OpenShift (OCP), VMWare Telco Cloud Automation (TCA), Wind River Cloud Platform, Kubernetes, Helm, Tanzu Kubernetes.	VMWare Telco Cloud Automation (TCA), HPE NFV Director, Samsung Cloud Orchestrator (SCO), Ericsson Orchestrator Evolved VNF Management (EVNFM), Ciena Blue Plant Orchestration (BPO).	VMWare Telco Cloud Automation (TCA), HPE Service Director, Samsung Cloud Orchestrator (SCO), Ericsson Orchestrator Service Orchestration (SO), Open Network Automation Platform (ONAP), Ciena Blue Plant Orchestration (BPO).

Limitations/Challenges in Current Solutions

The telecommunications industry is constantly evolving, and the need for an efficient end-to-end orchestration system has become more critical than ever. With the advent of new technologies like 5G, network slicing, and edge computing, the need for an orchestration system that can automate and manage the entire service lifecycle has become a necessity.

There are some challenges in adapting to Orchestration solutions available presently.

Interoperability Issues and Multi-Vendor Support

Many orchestration systems only manage and orchestrate a limited set of network functions and services, which restricts their ability to manage complex multi-vendor, multi-domain, and multi-technology networks.

Designing and implementing an orchestration system with a broader scope and managing a diverse set of network functions and services.

Flexible and extensible architecture that can easily accommodate new services, technologies, and vendors.

Integration with Legacy Systems

Many organisations have invested heavily in legacy systems, which can be difficult to integrate with modern orchestration systems.

Integration Challenges: *Different components use different interfaces, protocols, and data models, which can create integration challenges and require additional effort and cost to integrate them.*

Interoperability Issues*: Different components may not be compatible with each other, leading to interoperability issues.*

Scalability

One of the key limitations of current orchestration systems is their ability to scale. As networks grow and become more complex, orchestration systems must be able to handle increasing amounts of traffic, data, and processing power. However, many existing solutions struggle with this, leading to slow performance, long wait times, and potential downtime.

Distributed Architecture*: Creating a scalable orchestration system is designing a distributed architecture that can handle high loads and provide fault tolerance.*

Resource Management: *Efficient resource management, such as optimal placement of virtual network functions (VNFs) and monitoring of available resources.*

Load Balancing: *Distribute traffic evenly across all available resources while also managing the performance of individual resources.*

Complexity

One of the major limitations of current orchestration systems is the complexity involved in managing and orchestrating large and complex networks. With the increasing number of virtual network functions (VNFs), network services, and devices, the orchestration system becomes more complex, making it difficult to manage.

Managing several VNFs, network services, and devices.

Ensuring that the orchestration system can scale up or down to accommodate changes in network demand.

Dealing with the complexity of the underlying network infrastructure and ensuring that it is properly configured and optimised.

Lack of Comprehensive E2E Solution

Current solutions offer Orchestration capabilities for one or more layers only. For managing end-to-end Orchestration from bare metal servers to Network Services, CSPs need to deploy multiple solutions.

***No Single Pane of Glass**: Each solution has its own management interface. There is no single pane of glass which can be used to execute all Orchestration use cases.*

***Operational Cost:** Training the workforce on multiple tools is costly and time-consuming. Each vendor solution has its own interface, portal, and documentation.*

***Troubleshooting:** Troubleshooting issues across the technology stack is challenging as the user would need to check multiple siloed systems and co-relate logs to identify the root cause.*

Lack of Standardisation

Few orchestration systems lack standardisation in terms of interfaces, protocols, and data models, which can create interoperability issues and hinder the integration of different components from various vendors.

Integration Challenges: *Different components use different interfaces, protocols, and data models, which can create integration challenges and require additional effort and cost to integrate them.*

Interoperability Issues*: Different components may not be compatible with each other, leading to interoperability issues.*

Vendor Lock-In

Lack of standardisation can lead to vendor lock-in, where a specific vendor's technology is required to be used, limiting the system's flexibility.

Vendor lock-in poses several challenges, including limited flexibility, higher costs, and reduced innovation opportunities for the customer.

It can also lead to reduced competition among vendors, which may result in higher prices and reduced quality of service.

Manual Interference

Current orchestration systems may lack automation capabilities, requiring manual intervention for tasks such as resource allocation, service instantiation, and service scaling. This can lead to slow service delivery times, increased risk of errors, and reduced overall efficiency.

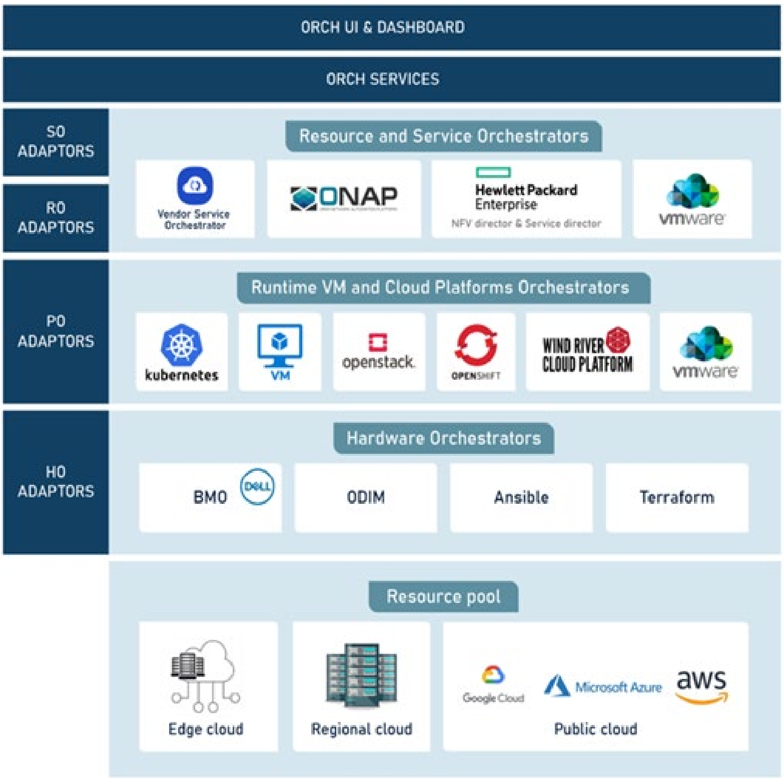
Designing an Automated Workflow: *The workflow should be designed to automate the entire service delivery process, from resource allocation to service scaling.*

Integrating with Existing Systems: *Integration with existing systems, such as network monitoring and management systems, to obtain the necessary data to automate service delivery.*

Benefits of Zinkworks Orchestration Framework and How it Solves the Problem

Zinkworks Orchestration Framework offers comprehensive and end-to-end Orchestration capabilities. It uses a modular architecture with adapters to enable integration with a wide range of legacy systems. Adapters are used to translate proprietary protocols and interfaces into standard formats that can be understood by the orchestration system. The adapters can be customised for each legacy system as needed, but the modular design allows for reusability and easier maintenance.

Adapters play a critical role in the Zinkworks Orchestration Framework, enabling integration with legacy systems. The adapters are designed to be modular, scalable, and reusable. Each adapter is responsible for translating the proprietary protocols and interfaces of a specific legacy system into a standard format that can be understood by the orchestration system. The adapters can be customised as needed, but the modular design ensures they can be reused across legacy systems. In addition, the adapters are designed to be scalable, allowing the orchestration system to support large-scale deployments with multiple legacy systems.



To manage a diverse set of network functions and services, the Zinkworks Orchestration Framework has several modules, including NFVO, VNFM, VIM, and MANO. These modules work together to orchestrate and manage the network functions and services across multiple domains and technologies.

The framework provides a modular architecture with well-defined interfaces and standard protocols, allowing customers to choose the best-of-breed components that suit their needs.

The framework also supports multi-vendor environments, enabling customers to integrate and manage services from different vendors.

Key Features of Zinkworks Orchestration Framework

- **Single Pane of Glass** for managing E2E Service Orchestration

- **One Solution** to manage the entire lifecycle of hardware resources, platform, VNF/PNF, and Services.

- **Adaptors-based modular architecture** for integration with multi-vendor and legacy systems while exposing unified APIs.

- **Unified API** layer provides a common interface for all legacy systems, regardless of their underlying protocols or interfaces. This API layer can be used to abstract the complexity of integration and provide a simplified interface for orchestration.

- Supports a **broad range of network functions and services**. The orchestration framework uses standard interfaces and APIs to integrate with various network elements, devices, and systems.

- Designed for **scalability and performance**. Highly distributed architecture allows for the handling of high loads and provides fault tolerance.

- **Dynamic placement algorithm** optimised VNF placement based on available NFVI resources for better resource management.

- **Policy-based orchestration** to automate complex network tasks, such as VNF scaling or service chaining. Policies are defined based on specific network requirements, and the orchestration framework automatically applies these policies to the network infrastructure.

- **Machine learning algorithms analyse network traffic patterns** and optimise network performance. The framework can automatically adjust network configurations to improve performance and reduce complexity.

- **Adopts standard interfaces, protocols, and data models**, such as the ones defined by ETSI NFV and ONAP. This can help ensure interoperability and enable the integration of different components from various vendors.

- Designed and implemented to ensure **no vendor lock-in** by using open standards and APIs, allowing customers to easily integrate and switch between different vendor solutions.

- **Reduce operational costs** by automating and orchestrating infrastructure software deployments and lifecycle management across multi-vendor environments.

Conclusion

A well-designed and implemented end-to-end Orchestration Solution can address many of the challenges faced by current orchestration solutions. By using Zinkworks Orchestration Framework, it is possible to integrate with legacy systems and overcome vendor lock-in. Moreover, standardisation and automation can be achieved to improve scalability, reduce complexity, and eliminate manual processes. The framework also allows for the integration of siloed systems, enabling a more cohesive and efficient orchestration process.

Zinkworks Orchestration System provides a comprehensive solution for end-to-end Orchestration Solution that can handle the complexities of modern networks and deliver the necessary agility, flexibility, and automation required in the rapidly evolving telecommunications industry.

For more information visit: www.zinkworks.com