



Executive Summary

ACG Research has been studying the evolving area of domain control and orchestration: automation of the network operations for individual network domains (domain control) and the orchestration of provisioning and optimization functions across domains (cross-domain orchestration). This paper represents a summary of some of the results of the research, focusing on the cross-domain orchestration market.

- Independent software vendors are dominating the cross-domain orchestrator market, while network element vendors mostly provide domain controllers,
- Cross-domain orchestration is most deployed in the transport area, providing end-to-end service orchestration across geographic domains as well as across IP and optical transport domains,
- Cross-domain orchestration for other areas is currently small but growing quickly,
- Netcracker is the leader in cross-domain orchestration software in 2022 with its Service and Network Orchestration software, part of its overall **Digital Platform** offering,
- Other top vendors include Ciena Blue Planet, Cisco (Sedona), HPE, Itential, and Nokia.

Further details are available in the forthcoming extensive research report.¹

Evolution of Cross-Domain Orchestration

CSPs' networks are large and complex with multiple interworked technologies requiring multiple skill sets and tools to plan, install, analyze, assure, and secure them. To manage and evolve their networks CSPs typically divide their deployment into domains, often defined by technology (such as optical transport, IP/MPLS or carrier Ethernet), by service (such as SD-WAN or residential broadband), by geography or along organizational boundaries. A tiered management structure has evolved that seeks to automate

¹ Mortensen, Mark H, *Cross-Domain Orchestration: Market Shares and Forecast, 2022*, ACG Research. To be published October 2022. This is part of an overall research program in Domain Control and Orchestration from ACG Research.

provisioning and assurance within a domain (using domain-oriented controllers and applications) as well as across domains (using cross-domain functionality, also called orchestration software).

The need to refine and evolve these implementations is creating the new Domain Control and Orchestration (DCO) category, progressively replacing element (EMS), network management systems (NMS), and many operations support systems (OSS), and expanding on the work begun in early stage SDN, NFV, and resource orchestration areas. It is being driven by the key economic imperatives of business agility (accelerating the pace of new services to the market), enabling more rapid innovation in service-chaining, and accommodating rapid scaling of successful services, often in a federated way. The software is being brought to market in both vendor and open-source initiatives. It is generally being implemented as a suite of cloud-native, model-based, API-driven, cloud-hosted modules that support the full life cycle of operations needed within and across an operator's domains and is increasingly linking northbound to higher level service and business management systems. It is a modular tier of software that streamlines and enhances the operation of a multivendor, multilayer, and multidomain network infrastructures, shown in Figure 1.

Domain Control & Orchestration (DCO) Software Systems Architecture

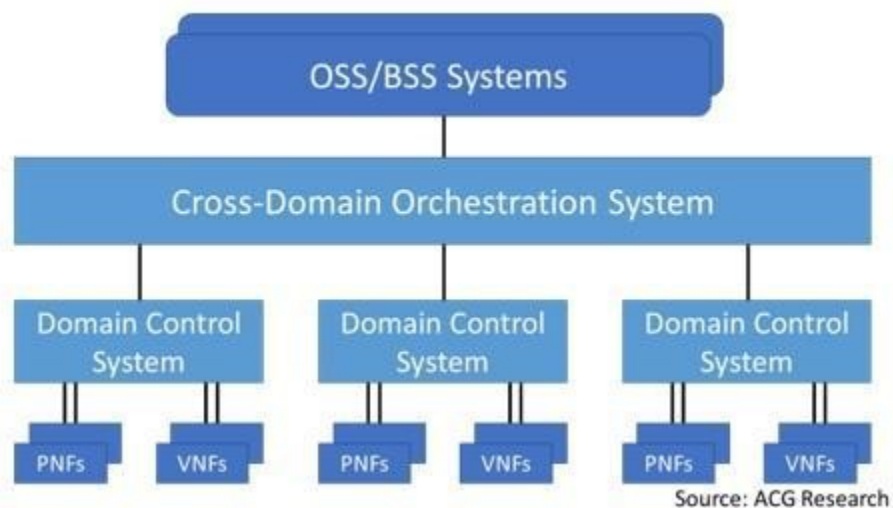


Figure 1. Tiered Architectural Model of DCO Software Systems (Source: ACG Research, 2022)

DCO Evolution Happening Now

The configuration, monitoring, and control of communications service providers' (CSPs) networks has been increasingly automated since the beginning of the electronic era in the mid-20th century through the application of software technologies to augment and, in some cases, replace human involvement in the operations. The OSSs that provided engineering, provisioning, and performance management were coupled to the network equipment through EMS and NMS, providing adaptation to those elements. These systems also delivered vendor-specific functionality and user interfaces for advanced features. But they were disjointed, manually intensive and led to siloed operations in the various parts of the network. This made it hard to ensure the end-to-end, multivendor automation that CSPs need to provide an excellent customer experience at low costs. It has hampered the CSPs in becoming more agile in creating, implementing, and scaling new services.

Point solutions expanding on NMS/EMS functionality have been pursued as steppingstones along the way to broader automation. These have included auto-provisioning for diverse packet/optical infrastructures via SDN control over the past half dozen years (working in parallel with EMS/NMS) and have also included specialized monitoring and analytics applications focused on measuring performance against service level agreements on multiple levels (working alongside EMS, NMS, and SDN control solutions).

Today, CSPs are seeking a new architecture that provides unified, responsive service delivery platforms that can meet the needs of widely varying consumer, enterprise, and public sectors. Key to providing this is the use of automation in a multivendor, multidomain environment. That is the challenge that has fueled the domain control and orchestration architecture that seeks to automate network operations to the greatest extent possible in building, augmenting, scaling, and operating the network and the growing list of services.

The Cross-Domain Orchestration Market

CDO provides functions that transcend the traditional OSS models. ACG Research has a new market segmentation model that places its functions primarily in the DCO market, with some exposure to the network provisioning and configuration and service provisioning markets, Figure 2.

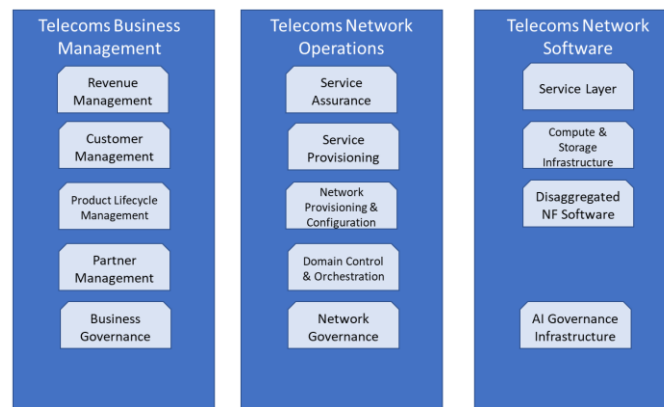


Figure 2. ACG Research OSS Market Segmentation

The cross-domain orchestration part of the DCO segment is a new and evolving market. We differentiate in the DCO model between modules that work on domain-specific functions and others that do cross-domain control and orchestration. We refer to them as domain control (DC) and cross-domain orchestration (CDO) software systems, respectively.

Domain controllers are generally being implemented as a suite of cloud-native, model-based, API-driven modules that support the full life cycle of operations needed within and across an operator’s domains. Increasingly, the suites include the domain-level provisioning and service assurance, along with a dynamic inventory cache that serves both. For slicing management, the slice design function is also often being added to these other functions.

Cross-Domain Orchestrators sit above the individual domains, linking northbound to higher-level service and business management systems. They provide a logically tiered arrangement of software that streamlines and enhances the operation of multivendor, multilayer, and multidomain network infrastructures. They often interface with other cross-domain service assurance and inventory functions

provided by specialist systems or exist as an application module in an integrated decomposable suite that includes provisioning, assurance, inventory, and sometimes design functions.

Domain Control Functions

At base, DCO functions include resource provisioning (adding network capacity and functionality and allocating resources to customers' services) and service assurance supported by analytics, along with an inventory of the network resources and implemented services. Together, these enable both human-assisted optimizations as well as closed-loop automation within the purview of the domain controllers for automatic resource management and control to maintain the quality of service needed for the services supported by the domain². If the required functions cannot be performed at the domain control level and within this domain, then they need the involvement of a cross-domain orchestrator to complete the task/s³. Similarly, a cross-domain orchestrator may recognize that actions are necessary within the context of a domain and call on one or more domain controllers to implement the actions.

Cross-Domain Orchestration Functions

Above the domain controllers are one or more CDOs. They take actions whose scope of effect stretches across two or more underlying network domains, and which are related to a function that needs either alignment or continuity across a combination of elements that must work together in support of an end-to-end service. They take input from the DCs, analyze and take actions within their purview, take inputs from and respond to requests from higher-layer systems. In some cases, the CDOs themselves may exist in multiple layers.

CROSS-DOMAIN ORCHESTRATION FUNCTION	DESCRIPTION
Cross-Domain Service Provisioning	Communicating with one or more domain controllers to provision network services in a single domain or that cross domain boundaries. Usually includes cross-domain path computation for connectivity services or slices.
Network Resource Optimization	Analyzing the configuration and usage of the network infrastructure across multiple domains and taking autonomous or directed actions to optimize the equipment utilization or quality of service.
Network Resource Provisioning and Adjustment	Initiating installation, configuration or adjustment (expansion, contraction or change) of a network resource (either virtual or physical) triggered either from upstream BSS/OSS or autonomously within the purview of the CDO.

Table 1. CDO Functions

² The services provided by the domain may be end-user services or services provided to more comprehensive end-user services that cross domains but require involvement of this domain.

³ The exception is the case of NFV infrastructure (NFVi), where a direct message can be sent to a domain controller for that area or sent to a higher-level cross-domain orchestrator.

Key Market Players

There are many players in the CDO market, some are from independent software vendors, some from network element vendors: Ciena Blue Planet, Cisco (Sedona), Ericsson, FRINX, HPE, IBM, Inmanta, Intraway, Itential, Juniper, NEC/Netcracker, Nokia, Oracle, and ZTE. ACG Research's interviews with CSPs have found that about two-thirds of the CSPs look primarily to independent software vendors for their CDO functions. Most of these vendors also play in the domain control market, providing multivendor domain control functions. Even the network element vendors (whether physical or virtual) provide domain controllers that work with their own equipment, as well as being able to be adapted to control other vendors' equipment (usually providing good enough support to others in cases where the vendor's equipment predominates).

Approximately two-thirds of the CSPs prefer the developer of their network functions (whether virtual or physical) for the associated DC functions, often choosing to operationally define major vendors' equipment as separate domains and using the CDO functions for coordination among them.

Most of the cross-domain orchestration market is currently within the transport area, since end-to-end services must be threaded across multiple geographic regions, across vendors' operational domains (as different vendors tend to dominate in different parts of the transport network), and across optical and packet transport domains, necessitating a cross-domain orchestration function.

Other cross-domain orchestration areas that are less well developed but are expected to grow substantially include:

- Edge, across access transport, mobile edge computing (MEC), and Internet of Things (IoT),
- Slices across the RAN, transport, and mobile core for mobile networks, especially for supporting MVNOs,
- Slices across fixed networks,
- Other vendor, geographic, organizational or technology domains that are operated as separate operational domains by a CSP.

MARKET SHARES

The 2022 market shares for the **top six** vendors of cross-domain orchestration software systems are shown in Figure 3.⁴ As expected from discussions with CSPs, independent software vendors dominate the market.

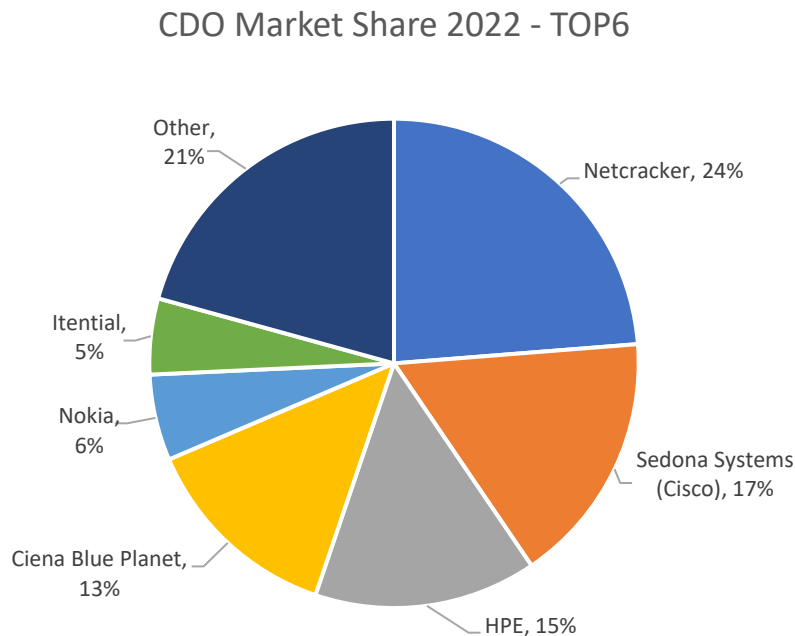


Figure 3. CDO Market Shares 2022

- Netcracker stands out as the market leader in providing cross-domain orchestration software solutions to CSPs worldwide. It is also most called out by CSPs and domain control vendors as a key partner for providing cross-domain orchestration. It has done over 40 service orchestration projects over the last three years, with about half being cross domain.
- Sedona Systems had established itself as a strong multivendor cross-domain orchestrator before its acquisition by Cisco.
- HPE was an early entrant in this market with its HPE Service Director, generalizing and building from its strong workflow technology using intent-based modelling.
- Ciena Blue Planet is an organizationally independent unit of Ciena, operating as an ISV, providing Ciena with its base domain control software for its own and other vendors' equipment as well as cross-domain orchestration with its Multi-Domain Service Orchestration offering.
- Nokia FlowOne supports service order management and CDO functions, along with a service catalog, provisioning and activation, unified inventory, and design functions.
- Itential is a fast growing ISV that has a large US and European base of Tier 1 CSPs that want to operate relatively independently by employing a cross-domain orchestration platform that is easy to configure, with an extensive library of predefined interfaces.

⁴ Mortensen, Mark H, *Cross Domain Orchestration: Market Shares and Forecast, 2022*, ACG Research. To be published October 2022.

NETCRACKER NETWORK AND SERVICE ORCHESTRATION

Our research places Netcracker as the leading provider of cross-domain orchestration software in the CSP market with its Network Orchestration system, a key component of the Netcracker Network Automation Solution and a part of its comprehensive Digital Platform offering⁵. Additionally, when queried, CSPs most often specified (to vendors) Netcracker as the company with which to work.

Cross-Domain Orchestration Offer Description

Netcracker provides an overall network automation solution (as well as all the BSS business functions) in its Digital Platform: domain control functions across the network, including RAN, MEC, transport and 5G xHaul, and network core domains. Across these domains, Netcracker adds its Network and Service Orchestration solution for end-to-end service orchestration.

Example Cross-Domain Orchestration Use Cases

Multilayer Transport Orchestration

Supports end-to-end automation across multilayer IP/MPLS, optical and microwave networks. Includes real-time multilayer network discovery and automated service provisioning and assurance for network services such as IP VPNs and IP/optical trunk provisioning,

Network Slicing

Supports the design, provisioning, and assurance of network slices across multiple domains, including a comprehensive inventory capability.

MEC and Access

Providing MEC and transport access integrated orchestration.

5G xHaul Transport Automation Solution with ADVA and Juniper Networks⁶

An integrated multivendor solution that includes ADVA and Juniper Networks for packet optical automation, combining their respective best-in-class technologies in support of streamlined 5G transport. With this solution, ADVA delivers secure optical connectivity, and Juniper provides automated IP WAN transport solutions, while Netcracker brings unified end-to-end multidomain service orchestration and automation expertise. NEC also provides xHaul Transformation Services as a part of the solution.

Example Customer Deployments

Deutsche Telekom Germany: Optical/IP Service Delivery⁷

Netcracker's Network Domain Orchestration solution installed in Deutsche Telekom to automate multidomain network discovery and visualization; multilayer traffic optimization; IP and optical backbone

⁵ Mortensen, Mark H, *Netcracker Digital Platform: A Comprehensive BSS/OSS SaaS Decomposable Suite*, <https://www.acqcc.com/blogs/2022/03/17/netcracker-digital-platform-comprehensive-bssoss-saas-decomposable-suite/>

⁶ <https://www.netcracker.com/news/press-releases/nec-and-netcracker-launch-5g-xhaul-transport-network-automation-solution-working-with-adva-and-juniper-networks.html>

⁷ <https://www.netcracker.com/news/press-releases/deutsche-telekom-germany-selects-netcracker-for-groundbreaking-network-and-service-automation-initiative.html>

provisioning; and multivendor network orchestration. Provides end-to-end network insight; automates complex service provisioning processes; and automates much of the operation to reduce operational expenses by about half. Was done through a collaborative DevOps process between Netcracker and DT's skills and experience. Future plans for this program include adding intelligent network planning and simulation as well as enhancing service assurance with AI.

"A combination of innovation, solution quality and ability to work using Agile/DevOps in a collaborative fashion demonstrated Netcracker's value as a strategic partner as we work together to revolutionize the way network services are delivered through end to end automation," said Rainer Steege, VP IP Core at Deutsche Telekom.

Domain Orchestration for IP and Optics

A T1 EMEA CSP employed the Netcracker solution for its B2B, B2C, and wholesale fixed and mobile telecoms services, including the service orchestration, active inventory, service assurance, IP address management, and equipment configuration management. It supported automated service provisioning across the IP and optical network domains, including real-time multilayer network discovery and reconciliation in a multivendor environment.

Cross-Domain Orchestration in B2B Domain

Deutsche Telekom used [Netcracker Service Orchestration](#) to automate its B2B services across multivendor software-defined WAN, LAN, and Wi-Fi (SD-X) environments. Netcracker is responsible for all aspects of the cloud-based solution, including build and deployment, and ongoing operations delivered as a [managed service](#).⁸

Edge Orchestration for Advanced Private 5G Services

E& (formerly known as Etisalat Group) has deployed Netcracker Edge Orchestration to provide orchestration across its MEC applications and the cloud-native 5G core resources.⁹ This will be used as it extends its managed private 5G offerings into additional vertical markets. It includes MEC application orchestration and platform management, NFV orchestration and management, service orchestration and slice management, active resource inventory, assurance and AI/ML to automate any combination of resources across distributed hyperscaler cloud platform from design to deployment, optimization, and assurance.

Other Customers' Deployments

Other cross-domain orchestration projects have been completed with over a dozen T1 and T2 CSPs in North America, EMEA, and APAC, including Andorra Telecom, ER Telecom, Globe Telecom, Segra, Shaw Communications, Turkcell, and Vexus.

⁸ <https://www.netcracker.com/news/press-releases/deutsche-telekom-brings-service-automation-to-b2b-domain-with-netcracker-service-orchestration.html>

⁹ <https://www.netcracker.com/news/press-releases/etisalat-uae-e-and-deploys-netcracker-edge-orchestration-to-offer-advanced-private-5g-services.html>

CONCLUSION

The CDO market is quickly evolving. Existing players in the OSS, network element and management systems being joined with new entrants are building the foundation of the software defined, autonomous networks of the future.

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industry expert in communications software for the TMT sector, with over 40 years of experience in OSS and BSS specifications, software architecture, product marketing, and sales enablement. His work has spanned the gamut of technical work at Bell Labs, strategic product evolution at Telcordia, CMO positions at several software vendors, and as a research director at Analysys Mason. Most recently, Mark has focused on the technology and processes of digital transformation for Communications Service Providers and the growing automation and orchestration of network and business processes. He joined ACG Research in 2018 where he has been responsible for Communications Software research and consulting. His research program, *Domain Control and Orchestration*, characterizes the state of network automation in the industry, profiles vendor solutions, and provides market shares and forecasts for this evolving market.

Netcracker

Netcracker Technology, a wholly owned subsidiary of NEC Corporation, offers mission-critical digital transformation solutions to service providers around the globe. Our comprehensive portfolio of software solutions and professional services enables large-scale digital transformations, unlocking the opportunities of the cloud, virtualization and the changing mobile ecosystem. With an unbroken service delivery track record of more than 25 years, our unique combination of technology, people and expertise helps companies transform their networks and enable better experiences for their customers.

ACG Research delivers information and communication technology market share/forecast reports, consulting services, and business case analysis services.

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