UNLOCK INNOVATION AND FUEL BUSINESS TRANSFORMATION WITH NETWORK SLICING

Juniper's Service Management Orchestration offering provides a modern, future-focused management framework that enables operators to offer and monetize custom network services on demand.

White Paper

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EXECUTIVE SUMMARY

The business landscape for new telecom services has never held so much potential for communication service providers (CSPs). With emerging 5G networks, CSPs can offer customizable network services for the first time, delivering network end-to-end slices tuned for specific use cases, applications, types of enterprises, and even individual customers. With these groundbreaking capabilities, CSPs can reduce capital and operating expenses (CapEx and OpEx). They can monetize their networks in new ways, launch new revenue models, and reinvent their role in the digital ecosystem. To do any of this, however, CSPs must first overcome a long-standing challenge: outdated, legacy approaches to service management that are past their prime.

Juniper Networks offers a vision of Service Management and Orchestration (SMO) for tomorrow's telco networks. Our SMO framework is designed from the ground up for highly dynamic, virtualized, cloud-native modern networks. It is purpose-built for 5G network slicing, so CSPs can provision, manage, and monetize custom network services on demand. It provides a framework to orchestrate and automate resources end to end, across all clouds and data centers, and all network domains, from radio access network (RAN) to transport to core. And it supports multitenant management of network slices—even by customers themselves—to unlock new Network Slicing as a Service (NSaaS) business models.

This white paper describes the changes transforming the telecom landscape and the reasons legacy service orchestration approaches no longer meet the needs of CSPs and their customers. It details the Juniper vision for a new approach to Service Management and Orchestration, and the ways our SMO can help CSPs take control of dynamic open architectures and use them to transform their business.

A Need for New Approaches in Service Management and Orchestration

The emerging telecom technology landscape represents a radical departure from anything that's come before. Multiple converging trends—cloudification, disaggregation, openness, software-defined everything—are redefining CSP networks and services, often more quickly than operators can keep up. The good news is that these trends unlock new capabilities and use cases that fuel business transformation for both CSPs and their customers. Using open radio access network (O-RAN) architectures, for example, CSPs can open historically closed, proprietary RANs to a growing ecosystem of third-party vendors and software innovations. Just as groundbreaking, they can use 5G network slicing capabilities to deliver customized network services on demand—and monetize them via guaranteed service-level agreements (SLAs).

These trends are enormously exciting, but they also bring huge changes to the ways CSPs build and operate their networks. Challenges include:

- **Evolving architectures**: CSP networks have been moving away from closed, monolithic solutions and toward virtualization, disaggregation, and openness. Emerging 5G and O-RAN architectures kick this trend into overdrive. Suddenly, telco networks need to function as open and disaggregated by design, using dynamic microservices architectures orchestrated with cloud-native platforms like Kubernetes.

- **Massive scale**: 5G introduces a highly distributed "planet-scale" infrastructure, where services are delivered from resources dispersed across thousands of clouds, and require specialized handling at tens of thousands of RAN sites.

- **Drive for on-demand service models**: What's the rationale for adopting new architectures? The ability to spin up new custom services on demand and deliver them under SLAs, like hyperscalers do with cloud infrastructure, and charge for them on an as a service (aaS) basis.

CSPs will overcome these challenges—the business potential is simply too great to ignore. To do it, they'll need to clear some significant technical and operational hurdles. Among the most urgent: a reliance on legacy service management and orchestration approaches that can't meet changing needs.

What's wrong with traditional management solutions? They're architected for legacy network architectures, to meet legacy requirements. Among other limitations, they're not designed with modern, open design principles or support for cloud-native microservices architectures. They can't support open multivendor ecosystems (like O-RAN) or service-based management architectures. And they can't meet the requirements of 5G network slicing.

Legacy element management systems (EMS) are also typically closed and proprietary, built for one vendor's equipment, with no way to interoperate in open environments like O-RAN. Traditional approaches are also typically siloed, designed for one network segment (RAN, transport, or core). They can't provide the end-to-end orchestration needed to deliver on-demand network slices that, by definition, require coordination across multiple network domains.

The biggest deficit of current management approaches, however, is that they're designed for a simpler, more static, legacy world. In the past, a CSP might provision a new service for a customer (a process that could take weeks or months), and once deployed, that service could remain unchanged for years. But network slices are not static. Slices are spun up on demand, configured for changing application requirements, and can have lifespans as short as a few hours. Often, network slices also are delivered under stringent SLAs, requiring automated closed-loop assurance—something that legacy management platforms simply can't accommodate.

To overcome these challenges—and to capitalize on 5G and O-RAN opportunities—CSPs need a fresh approach to service management, one designed to bridge the gap between modern software-driven architectures and the telco world. The list of requirements for such an approach is long. Any forward-looking solution must support:

- Cloud-native architectures and components
- Open, multivendor environments
- Flexible resource management at massive scales
- On-demand, end-to-end orchestration to support network slicing and new multitenant business models
- Support for strict SLAs with closed-loop automation
- "Experience-first" network and service operations

It's an ambitious vision, and Juniper Networks is making it a reality.

Unleashing Network Slicing in 5G Networks: Juniper SMO

As a global leader in telco network infrastructure and network automation, Juniper is developing a comprehensive SMO framework to help CSPs capitalize on open architectures, end-to-end network slicing, and on-demand service delivery. Others in the industry are taking baby steps—focusing on opening their closed legacy platforms, or trying to adapt antiquated EMS or operational support system/business support system (OSS/BSS) tools for modern cloud-native architectures. Juniper is building a framework for the future.

Juniper's Service Management Orchestration offering uses a new, clean-slate architecture, designed specifically for orchestration and automation at massive 5G scales. Recognizing that the purpose of new network investments is to monetize them, the offering is built from the ground up to treat network slicing as a core feature, not an add-on (Figure 1). It's open by design, using standardized interfaces to enable multivendor interoperability. Most important, it's designed to help CSPs take full advantage of highly dynamic, software-driven architectures to transform their business. The Juniper's Service Management Orchestration offering will deliver a management framework that is:

- **Multicloud**, to manage all network resources—across edge, regional and national data centers, and public and private clouds
- **Multidomain**, to orchestrate network slices end to end across RAN, transport, and core network domains
- **Multitenant**, to support enterprise customers, mobile virtual network operator (MVNO) partners, neutral hosts, and others, and deliver network slices tuned for each tenant's unique application requirements
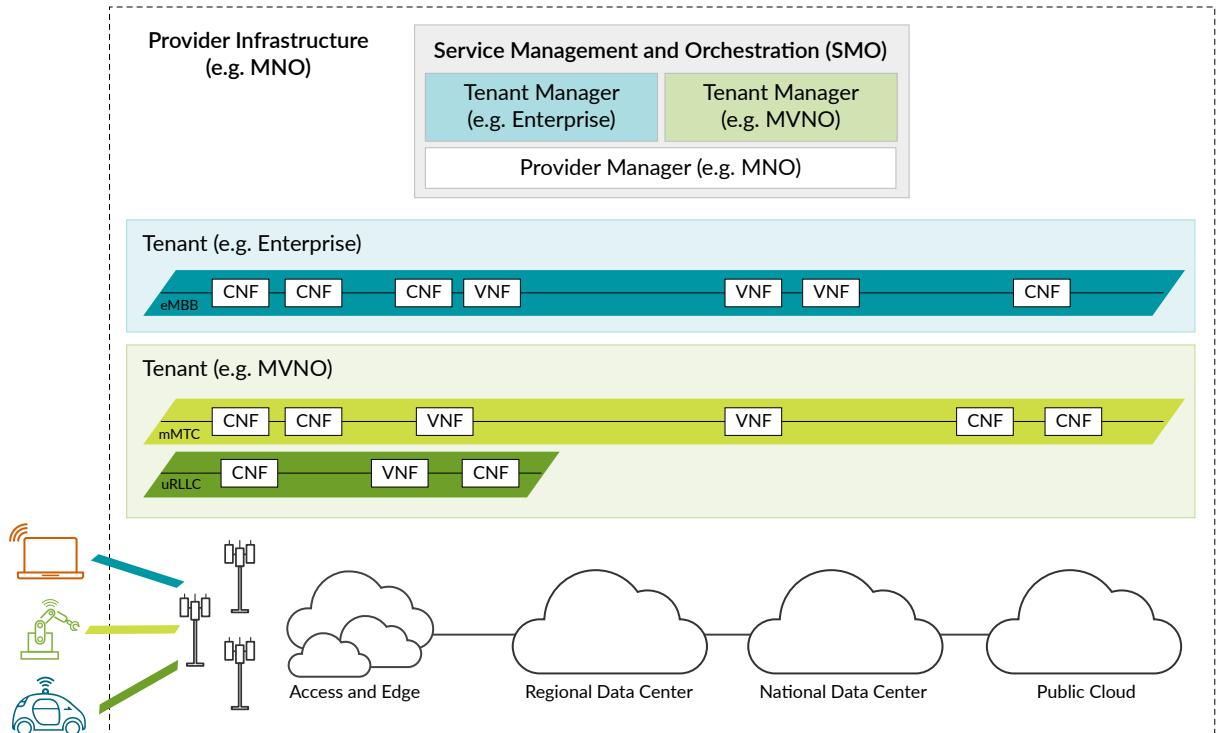
Figure 1. An SMO built for network slicing

Equipped with these capabilities, CSPs can provide:

- **End-to-end network slicing**: CSPs will create, manage, and monetize 5G network slices. They'll automate multidomain service orchestration. And with the ability to interoperate in open ecosystems using standard APIs, they'll continually tap into new vendor innovations.

- **O-RAN orchestration and control**: With Juniper's Service Management Orchestration offering, CSPs will take full advantage of open and disaggregated RAN architectures, and control complex multivendor RAN environments at massive scales. They'll manage O-RAN slice subnets automatically as part of end-to-end service orchestration. And they'll use RAN Intelligent Controllers (RICs)—the "innovation platform" at the heart of the O-RAN specification—to run third-party applications at the point of access that automate and optimize RAN operations at scale, and enable new use cases.

- **Business-to-business (B2B) and aaS models**: With an SMO designed for multitenant network slicing, CSPs will be able to support a range of new use cases, including private 5G, RAN sharing, MVNO, and neutral host. They'll even offer NSaaS, empowering customers and partners to create their own custom network services on demand.

Network Slice Management with the Juniper SMO Architecture

How will Juniper deliver this vision of a next-generation SMO? By providing a comprehensive framework for service orchestration that addresses RAN, transport, and core domains, along with end-to-end slice management across all of them (Figure 2). The following sections detail these components.
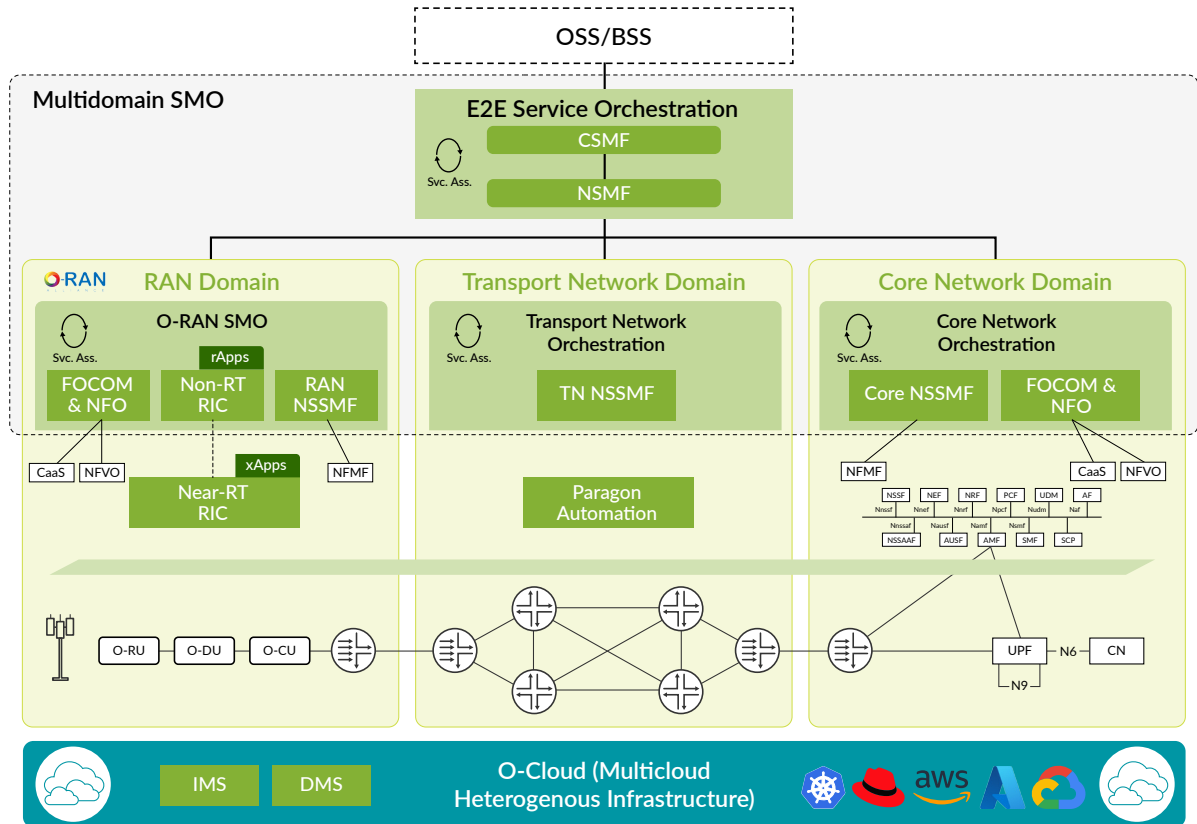
Figure 2. Juniper SMO framework

Network Slicing Management Functions

Figure 2 is a high-level illustration of the Juniper end-to-end vision, and it shows how the various components fit together across domains. Juniper's Service Management Orchestration offering consists of domain-specific modules to orchestrate network slices and resources in each subnet (O-RAN, transport, and core), all linked via a multidomain, end-to-end (E2E) service orchestrator. Together, this framework enables the on-demand creation and end-to-end management of network resources and slices across a distributed 5G infrastructure.

The Juniper SMO framework meets the 3GPP architectural requirements for network slicing. It does this via a new set of 5G Network Functions (NFs), each based on 3GPP specifications:

- **Communication Service Management Function (CSMF)**: This function receives service requirements from various sources (OSS/BSS, CSPs' users, NSaaS tenants, and others) and translates them into network slicing requirements. For example, imagine an enterprise customer wants to connect a smart factory for robotic automation. The CSMF determines that the customer needs a new network slice with guaranteed Ultra-Reliable Low Latency Communication (URLLC) characteristics. It then defines the high-level network slicing requirements to deliver that communication service and invokes the Network Slice Management Function (NSMF) to realize it.

- **Network Slice Management Function**: Once the CSMF determines the type of service required, the NSMF is responsible for orchestrating that slice. It identifies the resources needed to instantiate the end-to-end service and communicates with domain-specific Network Slice Subnet Management Functions (NSSMF) to assemble them.

- **Network Slice Subnet Management Function**: The NSSMF in each network segment (RAN, transport, and core) then instantiates the needed resources, as directed by the NSMF. Each NSSMF orchestrates the domain-specific resources in its subnet to fulfill the requirements for its part of the service. (Note: 3GPP uses subnet to refer to the different network segments that contribute to a service, not IP subnet.) So, for example, to deliver the smart factory service, the NSMF would direct the RAN NSSMF at each location serving that customer to assemble the

resources for a URLLC radio network slice subnet. Designed to orchestrate resources in disaggregated O-RAN environments, the RAN NSSMF then assembles all necessary components. That can include instantiating and configuring O-RAN Radio Units (O-RUs), O-RAN Distributed Units (O-DUs), and O-RAN Central Units (O-CUs), along with the necessary control and user plane functions. (See the following section for more details.)

As Figure 2 shows, a multicloud heterogeneous infrastructure underlies the entire architecture. Juniper's Service Management Orchestration offering uses an O-RAN-defined abstraction layer (O-Cloud) to orchestrate the infrastructure underlying each network domain and across the end-to-end environment. This allows CSPs and their customers to focus on service-level characteristics, while each subnet handles the granular details of orchestrating its underlying infrastructure. (Note that Juniper also extends this O-Cloud concept beyond the RAN and into the 3GPP world, applying similar principles and architecture to the end-to-end, multidomain environment.)

Each part of the architecture also feeds into a unified service assurance framework. CSPs can monitor slices across the heterogeneous environment and ensure that they consistently deliver exceptional experiences that can be monetized under SLAs.

RAN/Open RAN/O-RAN Domain

Figure 3 focuses on the RAN component of the Juniper's Service Management Orchestration offering, which aligns with the O-RAN specification for orchestrating network resources and services in a next-generation RAN.
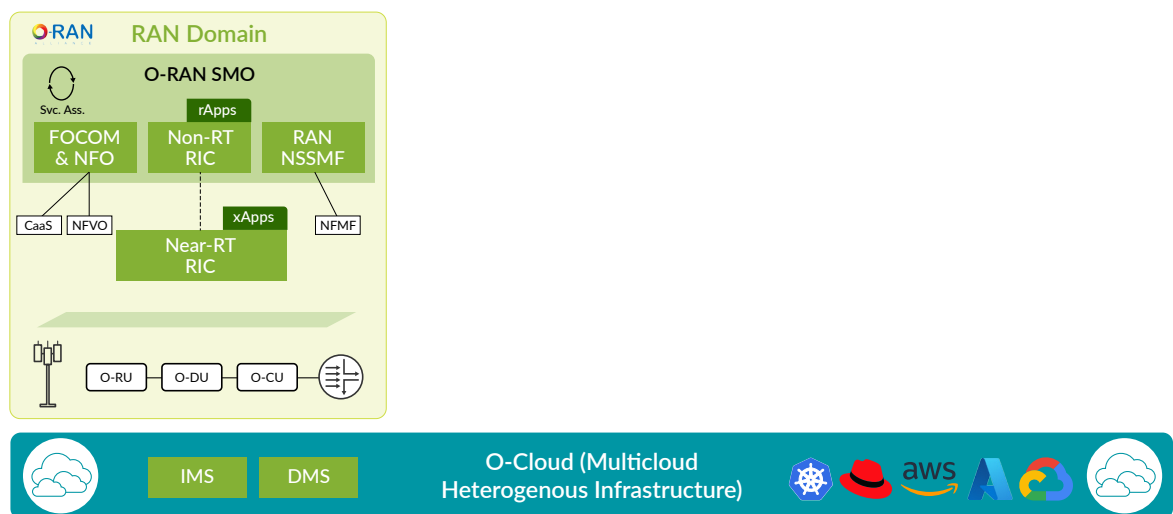

Figure 3. Juniper O-RAN SMO

The Juniper O-RAN SMO includes the following components:

- **RAN Intelligent Controller**: The RIC is like the operating system for the RAN. As a software-defined platform, the RIC brings intelligence, openness, programmability, and extensibility to radio access networks. The RIC uses AI and ML applications that automate RAN operations and support innovative use cases. With the RIC, network operators have a platform to deliver new functions and user experiences with greater agility and ease. Key elements of the RIC include the Non-Real-Time RIC (Non-RT RIC), the Near-Real-Time RIC (Near-RT RIC), and specialized applications called rApps and xApps.

  The RIC, together with the xApps and rApps, enables a diverse set of innovative RAN use cases, such as RAN slice SLA assurance, energy efficiency, traffic steering, and others. The Juniper RIC platform is based on a cloud-native microservices architecture and is fully compliant with O-RAN specifications and interfaces. It supports both an open API and a software development kit (SDK) for integration with any third-party O-RAN-compliant xApps or rApps, giving network operators greater flexibility and choice of suppliers. The Juniper RIC integrates with Juniper's Service Management Orchestration offering and other service management orchestrator platforms. For details, see the white paper "Unlocking Innovation and Value in the Radio Access Network."

- **Federated O-Cloud Orchestration and Management (FOCOM) and NF Orchestrator (NFO)**: O-RAN doesn't reinvent Container as a Service (CaaS) orchestration or Network Function Virtualization Orchestration (NFVO) platforms to manage RAN infrastructure and workload orchestration. Instead, it defines an abstraction layer (O-Cloud) to manage the underlying containerized and/or virtualized infrastructure using a common set of APIs. As defined by O-RAN, FOCOM communicates with the cloud platform to manage the underlying infrastructure resources, while NFO orchestrates the RAN network functions on top of them.

  To enable this, FOCOM and NFO (which are part of the O-RAN SMO layer) communicate with two O-RAN-defined modules in the O-Cloud: Infrastructure Management Service (IMS) and Deployment Management Service (DMS). The IMS allows the SMO to manage the O-Cloud infrastructure pool (all servers, networking resources, and data stores in a CSP's distributed data centers). The DMS enables orchestration of specific NFs, such as containerized DUs, deployed on that infrastructure cloud. In this way, CSPs can use the SMO to manage the full life cycle of all resources needed for a network slice—instantiation, activation, termination, and so on—anywhere in a CSP's RAN environment. Juniper's Service Management Orchestration offering integrates with third-party CaaS platforms like Kubernetes and ETSI MANO NFV workload orchestrators using ETSI-defined interfaces.

- **RAN NSSMF**: As noted, the RAN NSSMF is responsible for orchestrating the RAN portion of a network slice. In Juniper's Service Management Orchestration offering, the NSSMF is responsible for life-cycle management, configuration management, performance management, and fault management of RAN slice subnets. Furthermore, the RAN NSSMF interfaces with the RIC for control plane operations related to RAN slices.

To understand how these components work together, let's return to the hypothetical CSP deploying a new URLLC network slice for a customer's smart factory. The RAN SMO NSSMF receives direction from the end-to-end service orchestrator on the resources it needs to instantiate, and the way those resources must be configured, to deliver a network slice that meets the required SLA. (Note that this direction could come from a Juniper multidomain SMO, but it doesn't have to. Like all components of the architecture, the Juniper O-RAN SMO is open and standards-aligned, and can interoperate with third-party orchestrators.)

Next, the RAN NSSMF initiates the orchestration of the RAN slice subnet and its workload by invoking the O-RAN NFO. The NFO communicates with the FOCOM to understand the pool of resources available and their health and status. It then proceeds with "homing and allocation" of the NFs for the slice. (That is, it places NFs in the multicloud infrastructure based on factors like infrastructure availability and topology, workload hardware requirements, affinity/anti-affinity requirements, and slice design SLA requirements). The O-RAN SMO then monitors the slice on an ongoing basis, in conjunction with the CSP's end-to-end service assurance framework, to verify that it's meeting the required SLA and takes automated corrective action if it's not.

Transport and Core Domains

In addition to orchestrating the RAN, Juniper will offer SMO solutions for transport and core domains (Figure 4). Like the O-RAN SMO, these solutions will be open and aligned with the relevant standards (including 3GPP, IETF, and TM Forum) for domain-specific and end-to-end networking slicing.
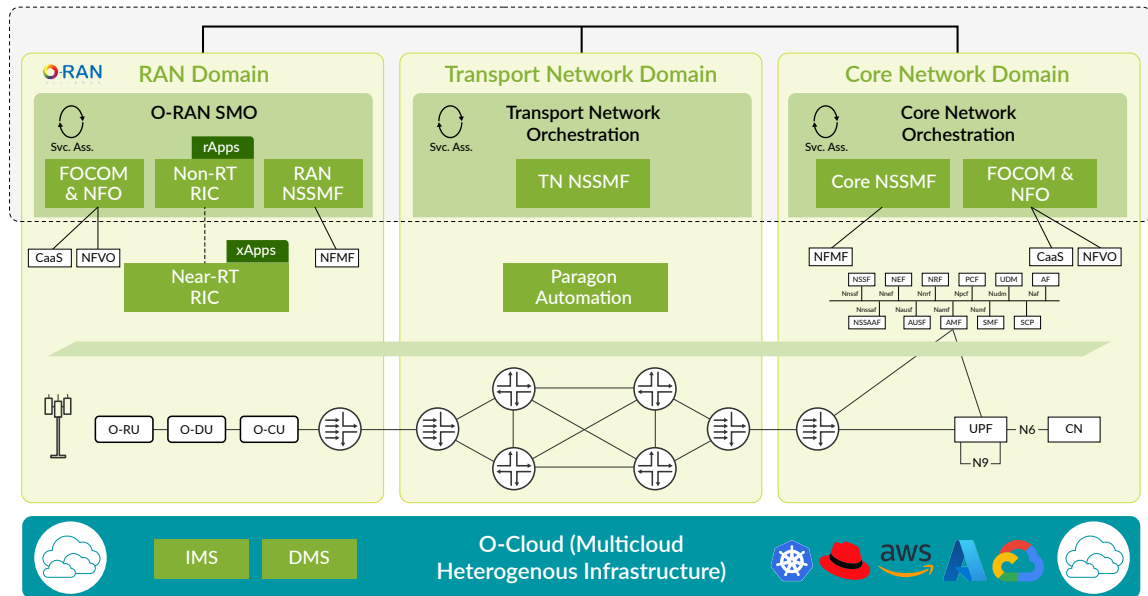
Figure 4. Extending orchestration across transport and core networks

Note that, while Figure 4 depicts RAN, transport, and core as separate entities, they may be more tightly integrated and interrelated in real-world networks. In a disaggregated RAN, for example, RUs could be hosted at cell sites, DUs in edge clouds, and CUs in regional clouds. In this case, a CSP would use transport network orchestration to manage networking across fronthaul, mid-haul, and backhaul clouds, as well as between RAN and core. Furthermore, 5G core components can also be disaggregated, and some 5G core NFs can even be collocated at the same cloud location as other functions from the RAN (for example, a 5G core UPF collocated with a RAN CU-UP). Bottom line: end-to-end slice topology and transport connectivity requirements can quickly grow complex and overlapping.

Juniper will offer SMO solutions for:

- **Transport Network Orchestration**: Juniper's Service Management Orchestration offering defines a Transport Network NSSMF to assemble transport resources and orchestrate them as part of an end-to-end network slice. Here, Juniper can offer unique value through our industry-leading Juniper® Paragon Automation suite of solutions. Juniper already provides comprehensive tools to simplify life-cycle management of transport infrastructure, accelerate service delivery, and assure consistently excellent service experiences with closed-loop automation. Through the SMO, Juniper can extend these capabilities to support end-to-end orchestration for on-demand network slices and NSaaS.

- **Core Network Orchestration**: Juniper's Service Management Orchestration offering for core networks will follow the same architectural framework as the RAN, using the same FOCOM and NFO components to control the underlying O-Cloud and NFs. Here though, those components will orchestrate the full range of virtualized and cloud-native network functions that comprise a 5G core network. Additionally, the Core NSSMF will integrate with third-party 3GPP-aligned NF Management Functions (NFMF) to manage 5G core NFs as part of an end-to-end network slice.

A Modular Solution

The Juniper SMO framework provides a vision for end-to-end orchestration of network slices across domains, along with domain-specific orchestrators for RAN, transport, and core. However, the SMO is open and modular by design. CSPs can use all parts of the solution together or select individual components as they choose. CSPs will be able to deploy:

- **RIC**: Use the Juniper innovative, O-RAN-compliant Near-RT and Non-RT RIC platforms—either together, as standalone solutions, or pre-integrated with the Juniper multidomain SMO.

- **O-RAN SMO**: Start taking advantage of O-RAN now, even before implementing end-to-end slicing capabilities, using the Juniper O-RAN SMO as a standalone solution.

- **Multidomain SMO**: Use the Juniper end-to-end orchestration capabilities to simplify management across the network and start enabling transformative network slicing use cases. The Juniper multidomain SMO is a superset solution that includes the Juniper RIC and O-RAN SMO, along with end-to-end network slicing management capabilities. It provides end-to-end service orchestration (CSMF, NSMF), as well as management of transport and core network slice subnets.

The Juniper SMO Advantage

Why is Juniper's Service Management Orchestration offering the best choice for implementing a modern, future-focused management framework? Juniper's Service Management Orchestration offering is:

- **Built for network slicing**. Emerging architectures introduce a dizzying mix of new software technologies and cloud-native approaches to CSP networks. In this new world, network management vendors focus on many different areas, and it's easy to get lost in the technical details. At the end of the day though, CSPs invest in 5G and O-RAN to enable new use cases and revenue streams. It's through network slicing that CSPs will transform their businesses. That's why any viable approach to management can't treat slicing as an afterthought. The Juniper SMO, and innovations in RIC, transport, containerization, and automation, are all designed to help CSPs implement and monetize end-to-end network slicing as quickly as possible.

- **Designed with a clean-slate architecture**. 5G and O-RAN introduce radically new ways of working to telco networks and operations—but you wouldn't know it from looking at some vendors' SMO strategies. Some traditional management/OSS vendors looking to enter this space have no experience with the RAN, RIC, and transport components needed to orchestrate end-to-end network slices. Others attempt to address 5G requirements with refactored 4G architectures designed with assumptions that no longer apply. Meanwhile, legacy RAN vendors are trying to build credibility in open ecosystems after years of selling closed, monolithic solutions and proprietary EMS tools. Juniper takes a completely fresh approach. Juniper's Service Management Orchestration offering is a state-of-the-art solution, written as dependable, high-efficiency software using modern programming languages and design principles.

- **Uses open interfaces and aligns with industry standards**. Central to the Juniper vision for the future of CSP networks, Juniper's Service Management Orchestration offering is designed for openness and flexibility. Juniper uses open interfaces across the architecture (Figure 5) to bring multivendor ecosystems and innovation to telco networks. By exposing APIs defined by 3GPP, TM Forum, and others, Juniper makes it easy for CSPs to link the modular components of our solution with third-party orchestrators. And Juniper isn't just a proponent of open APIs; we play a lead role in the O-RAN Alliance, IETF, and other industry groups defining them.
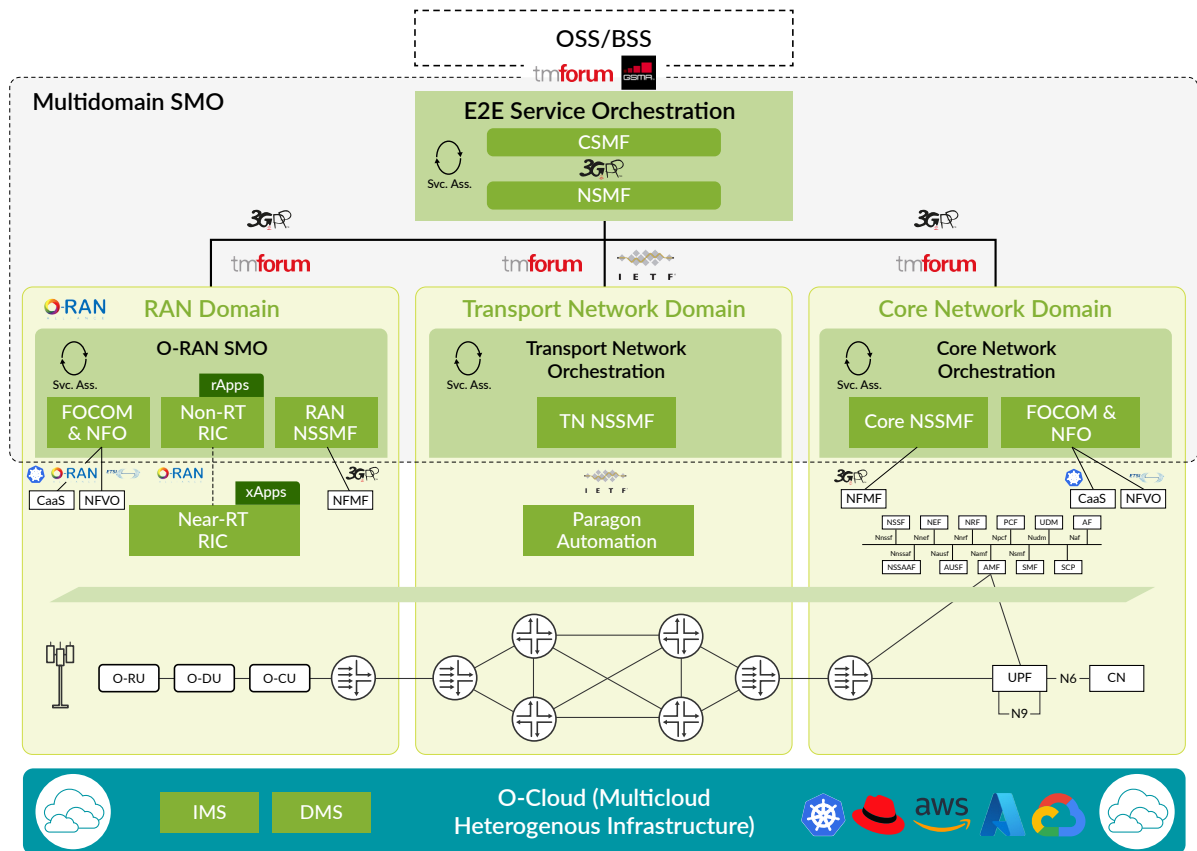
Figure 5. Open standards and interfaces

- **Supports multiple use cases**: Juniper focuses not just on enabling new capabilities, but on helping CSPs make the most of them. In addition to 5G network slice management and O-RAN orchestration, the Juniper SMO brings flexibility to support many emerging use cases. CSPs can offer a range of private wireless solutions, with deployment options for virtual private networks, on-premises private networks, standalone private networks, and private networks for neutral host and RAN-sharing environments. With an architecture designed for multitenancy, the Juniper SMO makes it easy to launch new B2B use cases like MVNO and NSaaS.

- **Enables superior operator and customer experiences**: Everything Juniper does starts with the "Experience-First Networking" philosophy—the principle that every aspect of a network should relentlessly focus on service experience. That philosophy extends to the CSP operations teams delivering those experiences too. Our entire approach to network slicing—on-demand resource orchestration, closed-loop automation, simplified management of multivendor environments, and more—is designed to make it easy to deliver exceptional customer experiences.

Juniper: Leading the Way in Network Slicing, O-RAN, and SMO Innovation

SMO for 5G and O-RAN environments is a brand-new field, encompassing novel technology innovations in multiple areas. Unlike many vendors now entering this space, Juniper already offers proven leadership in many of them, including:

- **Open RAN**: In addition to leading the market in telco network programmability with our RIC, Juniper is playing a key role in defining tomorrow's RAN standards. Juniper is a founding member of the O-RAN Alliance and currently contributes to seven working groups, leads the slicing and use case task groups, and serves as editor for RIC and transport specifications.

- **Next-generation transport**: As a long-time leader in enterprise and CSP transport infrastructure, Juniper played a central role in defining transport network slicing with IETF. And with Paragon Automation, Juniper is building unmatched capabilities to automate WAN operations.

- **Cloud-native networks**: Juniper is helping organizations worldwide tap into the benefits of software-defined networking (SDN) and agile, microservices-based architectures with solutions like Juniper® Cloud-Native Contrail Networking.

- **Artificial intelligence and machine learning**: Distributed telco networks need advanced AI/ML capabilities to monitor network resources and assure services at massive scales—and Juniper leads the industry in enabling them. The Juniper RIC platform supports multiple AI-driven xApps and rApps to fuel RAN innovation and agility. Juniper Mist AI™ solutions set the standard for diagnostic and automation capabilities in enterprise wireless networks. And Gartner named Juniper "Furthest in Vision and Highest in Execution" in the 2021 Gartner® Magic Quadrant™ for Enterprise Wired and Wireless LAN Infrastructure.

- **Open ecosystems**: Juniper doesn't just talk about the value of openness, we deliver it. Open interfaces and multivendor interoperability are core design principles of Juniper's Service Management Orchestration offering. And we've proven our commitment to open ecosystems. Juniper is already working with technology leaders like AirHop, Casa Systems, Intel, Parallel Wireless, Rakuten, and others to bring new RAN innovations to CSPs via our open RIC platform.

Take the Next Step in Telco Transformation

Want to learn more about how Juniper can help you capitalize on 5G and O-RAN to transform your business? Visit: Juniper 5G Networking and Automation Solutions.

About Juniper Networks

At Juniper Networks, we are dedicated to dramatically simplifying network operations and driving superior experiences for end users. Our solutions deliver industry-leading insight, automation, security and AI to drive real business results. We believe that powering connections will bring us closer together while empowering us all to solve the world's greatest challenges of well-being, sustainability and equality.

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