

# Nokia

## Cross-Domain Service Orchestration

Author: Grant Lenahan – Principal Analyst



Published by Appledore Research LLC • 44 Summer Street Dover, NH. 03820

Tel: +1 603 969 2125 • Email: [info@appledorerg.com](mailto:info@appledorerg.com) • [www.appledorerresearch.com](http://www.appledorerresearch.com)

© Appledore Research LLC 2022. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, mechanical, photocopying, recording or otherwise – without the prior written permission of the publisher.

Figures and projections contained in this report are based on publicly available information only and are produced by the Research Division of Appledore Research LLC independently of any client-specific work within Appledore Research LLC. The opinions expressed are those of the stated authors only.

Appledore Research LLC recognizes that many terms appearing in this report are proprietary; all such trademarks are acknowledged, and every effort has been made to indicate them by the normal USA publishing standards. However, the presence of a term, in whatever form, does not affect its legal status as a trademark.

Appledore Research LLC maintains that all reasonable care and skill have been used in the compilation of this publication. However, Appledore Research LLC shall not be under any liability for loss or damage (including consequential loss) whatsoever or howsoever arising because of the use of this publication by the customer, his servants, agents or any third party.

Publish date: 6/21/2022

Cover image Photo by [Arindam Mahanta](#) on Unsplash

## INTRODUCTION

This profile is one of many in a series that accompanies our research stream on [Cross-Domain Service Orchestration](#).

Two of the key strands of Appledore's research are the need for **innovation and automation** – and that there are right and wrong ways to approach each. Innovation is not only about technology, but also about of *commercial* innovation. Myriad new revenue opportunities, from IoT, to private 5G, to “digital services” depend on new business models and the ability to quickly and inexpensively combine communications capabilities with those of industrial and commercial verticals. For example, CSPs must be able to sell “as-a-Service” and also to increasingly consume external capabilities “as-a-Service”, based on business need. In our recent research on [Telco as a Platform](#) we looked at the opportunity from the disaggregation of telco, outlining how telco in the future will increasingly be built from ecosystems of platforms, each providing disaggregated components of network.

**Cross Domain Service Orchestration** is the single process that will create these new, end-to-end services and unlock incremental revenues. To accomplish this, orchestration must facilitate the agile combination of pre-existing “services” from within a telco *and from many external partners*. In this way, pre-built, pre-tested and loosely coupled building blocks become the basis of rapid innovation. By way of example, we are already seeing this model generate market success in the **revitalized enterprise market**, with SDWAN, public cloud, broadband “underlay”, private enterprise resources and on-demand cloud-based network functionality chained together, dynamically. While built from the same “building blocks” each of these customers’ environments are unique, and in fact change dynamically. The market for private 5G, “network slices” and servicing IoT consortia all promise similar opportunity with similar operational needs.

The common thread across all of these is that we cannot anticipate future services. Corollary to that, there will be many combinations and permutations of services that must be created and managed. Much of this innovation may occur outside our industry's control – by innovative enterprises & System Integrators in the healthcare, automotive, advanced manufacturing, etc. Operational platforms must prioritize easy, fast, cheap innovation.

Simultaneously, new network technologies promise flexibility & efficiency one the one hand, and vastly greater complexity on the other. Both demand automation to first reign in cost, and then to achieve the cost improvements possible through cloud native and configurable, smart technologies such as 5G, SDN, SDWAN and others.

These concepts are becoming widespread, and endorsed by standards, although the face of each “standard” looks different. The MEF (Legato and Sonata), TMF (APIs, Open Digital Ecosystem), and 3GPP (network slicing) are all working on implementations that focus on re-usable components, customized services, and integration with components in the outside world. This is true progress, and like most progress, is slightly messy if you look too closely and take each too literally. Yet we observe clear direction.

The cross-domain orchestration market is embryonic, and like all new markets, many suppliers are competing, and following different playbooks. NEPs come from one perspective, traditional “OSS” ISVs from another, the IT heavyweights from a third, and finally, there are several new disruptive entrants with unique propositions. Over time the market will work out what works, and what is popular. The critical take-away is that understanding the market may be more about “what are your needs and abilities as a CSP” than about “which vendor does it best and cheapest”. Why? Because there is not one answer or one approach (so far) that fits the needs of all. We strongly encourage interested readers to read our major Market Outlook Report which dives into this market and forms a foundation within which this and other profiles are best read.

In this profile we look at how **Nokia** with its “Digital Operations Center” solution, proposes to deliver these above mentioned capabilities. Appledore will cover individual domains (e.g.: cloud native orchestration for datacenters and edge), SDN, and SDWAN in related but separate research tracks.

### NOKIA DIGITAL OPERATIONS CENTER

Nokia positions Digital Operations Center as an overarching, cross-domain service orchestration layer for next-gen telecom operations – in particular for 5G networks - sitting above lower-level domain controllers or orchestrators. Nokia has taken key concepts of cloud-native (as they apply in a data center domain) and applied them in a multi-/cross-domain context. Digital Operations Center is the cross-domain offering, distinct from the underlying domain controller capabilities.

Nokia Digital Operations Center is a modular solution comprised of Orchestration Center and Assurance Center leveraging a common Unified Inventory. With the Unified Inventory, Nokia has built a near real-time single source of truth view of the network and services as well as the relationships between the services and the corresponding network functions and the underlying infrastructure resources. This combination gives CSPs the ability to manage the entire service lifecycle by designing, delivering, and assuring digital services and 5G slicing at scale and speed. It is *not* however, monolithic. While the components are designed to work together, Nokia Digital Operations Center can work with other inventory and assurance solutions – so long as they provide the capabilities necessary. We note that Nokia’s use of the term “inventory” can be misleading – it is really a bidirectional service dependency graph used to support cross-domain impacts (“a depends on b”). This is consistent with Appledore’s reference view.

Digital Operations Center supports numerous standards where and as they apply to include TMF, ETSI, MEF, 3GPP, BBF, ONF and IETF. It also has a “single pane of glass” family of Hubs – DesignHub, OrderHub, OperationsHub, IntelligenceHub – for the management of end-to-end lifecycle of services or network slices (design-deploy-assure) and supports CAAS deployments based on Kubernetes (such as GCP, Azure etc.)

To summarize the offering, it is:

- Multi-vendor, multi-domain
- Explicitly embracing fulfilment, assurance and their dependency inter-relationships
- Network slicing focused
- A “network-aware, closed loop solution”

- Runs locally or on any cloud.

Some important capability sets of the Digital Operations Center are:

- Template-driven onboarding of new services or slices - including SLAs and policies for ordering and assurance.
- Service ordering and fulfillment - assigning the network resources as required by the service and respective SLAs.
- ML-based AIOps closed-loop automation for QoS preventive and automated assurance avoiding SLA breaches

## Competition and Market

Nokia Digital Operations Center competes with a wide range of competitors, large and small. These range from the other major NEPs (**Ericsson, Huawei** ...), to large IT firms (**HPE, IBM, Oracle**, ...) to telecom ISVs (**Amdocs, Blue Planet, Netcracker\***, ...) to the many specialists and innovators that are not only challenging, but in some cases establishing significant beachheads (**Itential, Inmanta**, ...).

As we discuss at length in our recent Market Outlook Report on the Cross-domain Service Orchestration market, we are seeing significant segmentation with players that offer different combinations of product strengths, and delivery/services strengths such that choice is often a matching of a supplier's packaging and emphasis to a CSP's unique needs and aspirations.

## Positioning and Strategy

Nokia has one of the largest and broadest NAS portfolios in the industry. In our recent NAS market share report, they ranked #1 – in part based on their extensive set of domain managers/orchestrators. This is relevant to cross-domain orchestration in that it underscores Nokia's adherence to, and understanding of, domain-driven design. "You can't manage what you don't understand".

Sitting a layer above those domains, Nokia has recently completed the creation of Digital Operations Center as a clean-sheet product for cross-domain service orchestration orchestrations solutions. It is a bet on new software to support new operational methods for new network services and technologies. Nokia also emphasizes that it is not a focus play on network services only; per Nokia: *"Nokia's service orchestration solution is designed to support any current and emerging use case, independent of the underlying network technology."* As the industry moves toward innovation based on digital services, 4IR, etc., this is an important position.

Nokia also walks a line, balancing claimed multi-vendor support, standards support and at the same time, the tremendous advantage of pre-integration with its own domain controllers and network technologies including access, optical, IP, RAN and core. This pre-integration, while it can be derided as "single vendor" is in fact achieved through open, loosely coupled interfaces and models, and its very existence reduces cost, effort and risk for smaller SPs that cannot entertain large custom projects. In some ways we view Digital Operations Center as both build "up" from strong

network domains, while looking “down” from a perspective of innovation, management and automation across arbitrary domains – technical or administrative.

Nokia’s Digital Operations Center has both the benefits of being new (modern, lack of compromises) and the penalties (few commercial deployments ... yet). That said they documented some deployments and many PoCs/trials in process and given their software base we expect Digital Operations Center to become widely deployed.

## ARCHITECTURE AND CAPABILITIES

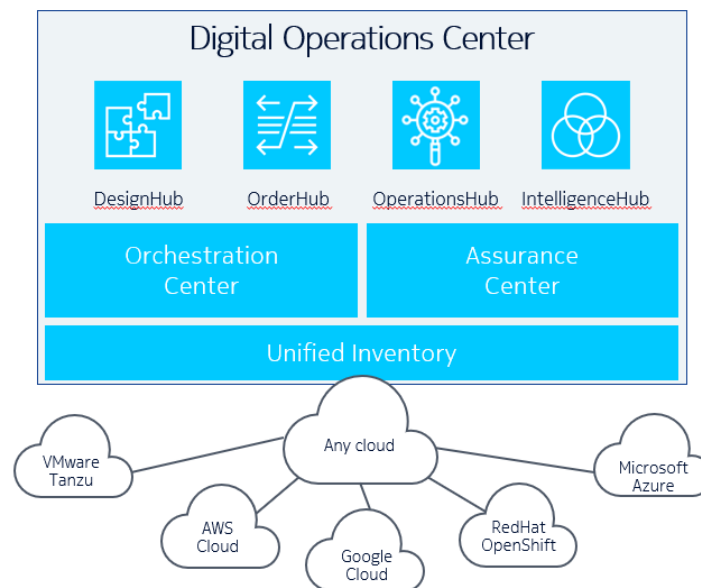
Fundamentally, Nokia’s Orchestration Center is one of three inter-dependent yet modular products:

1. **Orchestration Center** – the intent based orchestration engine for all processes in the closed loop.
2. **Assurance Center** – the assurance, root cause and analytics engine that informs healing and scaling actions executed by Orchestration Center
3. **Unified Inventory** – the bi-directional dependency graph that links domains and services together such that design decisions and root causes may be determined and impacts easily inferred (e.g. this depends on that, so if that fails, this will be impacted)

Nokia emphasizes that these relationships may be used at many different points in a resource or services’ life-cycle, and likely for many business actions as well.

The diagram below illustrates Nokia’s high level architecture, with Orchestration and Assurance sharing a common “inventory” (need not be theirs), and below offline design tools, order management and intelligence sources. The clouds below merely reference environments that it can run on, cloud-natively.

**Figure 1: Major Modules of Digital Operations Center**





Source: Nokia

### Cloud-native, Catalog based and service innovation

The first of the three major components, **Orchestration Center**, is cloud-native and supports deployment on any cloud platform, thereby leveraging the agility of the cloud for faster launch of new services. Its high degree of simplification, rich set of off-the-shelf service templates, open northbound APIs (aligned with 3GPP, TM Forum) and southbound adapters simplify integration across multi-domain multi-vendor systems for better agility and faster time to market.

Orchestration Center is intended as the central place for service “assembly” from components, and therefore innovation. It performs catalog-based service orchestration and lifecycle management of 5G (or other) end-to-end slices and other services with the **right level of abstraction (low-code approach)**. It supports integration with multi-vendor domains and automates the orchestration of the telco cloud and cloud-native application domains, as well as configuration of physical network domains.

Nokia focusses on abstracting technology to services – whether these are externally consumed, or consumed as components of a more complex end-to-end network or customer service. Its goal is to meet service performance goals while hiding the operational complexity of the network underneath. Orchestration Center supports the NaaS paradigm by interworking across domains and providing flexible and dynamic means to design and deploy the service. Combined with Assurance Center, Orchestration Center provides the means to monitor service performance.

### Intent-based

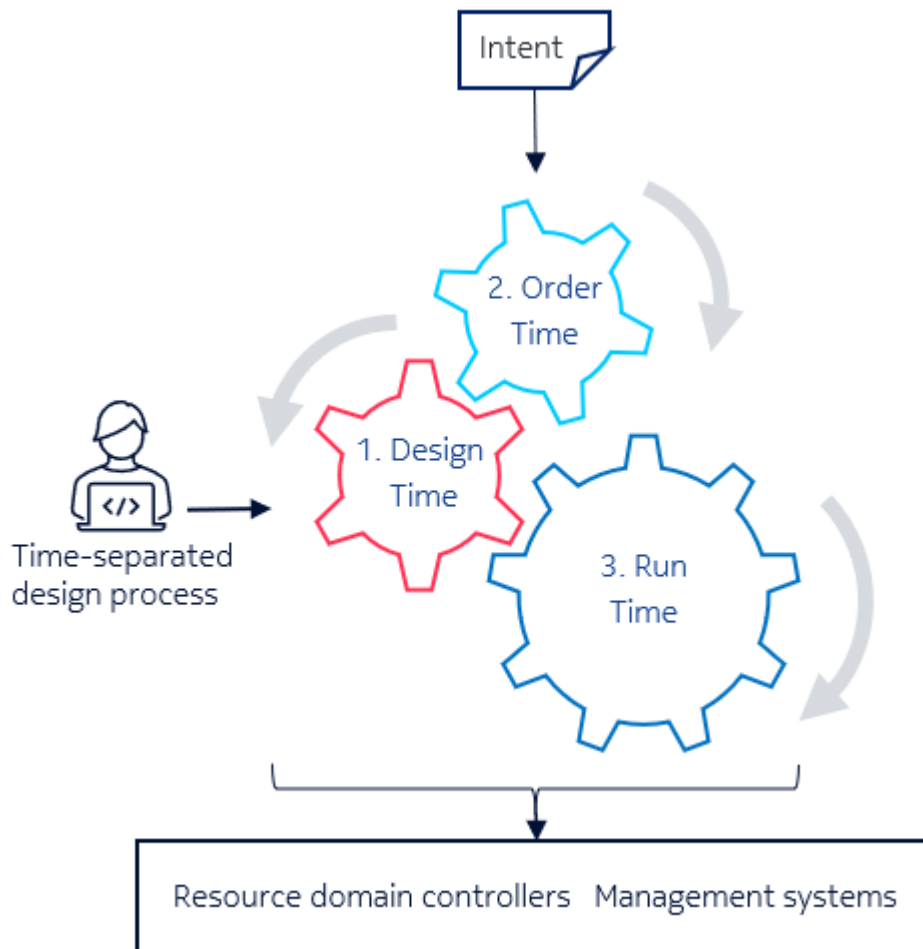
Why is intent important? The long answer is provided in “[Why Intent Matters](#)”. But the short answer is that it allows for simpler development and innovation, less maintenance and enhancement effort, and is essential to letting domains self-manage. The last in particular is why it is a core pillar of the cloud native computing foundation (CNCF).

The figure below outlines Nokia’s approach to intent-based service orchestration. The color schemes are important to indicate the time-separated flows that are involved in the overall service lifecycle:

1. **Design time** (red): Time-separated design process to expose the e2e services with associated policies which include constraints for the SLAs, thresholds, etc. The e2e service is composed of the resource facing services which are re-usable building blocks (models) which can be onboarded from the domains or designed as per need.
2. **Order time** (light blue): Instantiates (fulfills) a service, whether simple (within a domain) or more complex (across multiple domains). Orchestration Center performs dynamic service decomposition based on order intent, policy and network availability. In turn, Orchestration Center interfaces southbound to the underlying domains with loose coupling techniques using declarative or imperative methods based upon the capabilities of the southbound systems and the CSP’s preferences.

3. **Run time** (dark blue): once a service is in production, the closed-loop engages. This applies assurance data to SLAs and uses the unified inventory graph to determine impacts and dependencies. Then, the closed-loop, using the original cloud-native methods, can amend the scale, location or other parameters to ensure SLAs (defined during service onboarding/creation) are adhered to.

**Figure 2: Support for Intent in Digital Operations Center**



Source: Nokia

The solution creates specific instances (solutions) from intent based definitions, using rule-based algorithms as well as problem-solving algorithms for the purpose of constraint satisfaction and optimization. The latter ones are part of the AI driven policies.



As depicted in Figure 1, Digital Operations Center relies on Nokia's Unified Inventory for these functions. As such, there is no topology / inventory data cached in Orchestration Center nor in Assurance Center. Instead, this information is within the Unified Inventory module. Unified Inventory is a cloud-native GraphDB system.

While domain managers have everything they need to manage the network functions (NF's), Unified Inventory provides the unified information model for orchestration, fulfillment and assurance. The model recursively connects physical, logical, virtual, and service resources of the multi-domain, multi-vendor networks in one connected topology.

Digital Operations Center's architecture is consistent with Appledore's best practices/reference closed-loop architecture.

### APIs and Standardized Interfaces

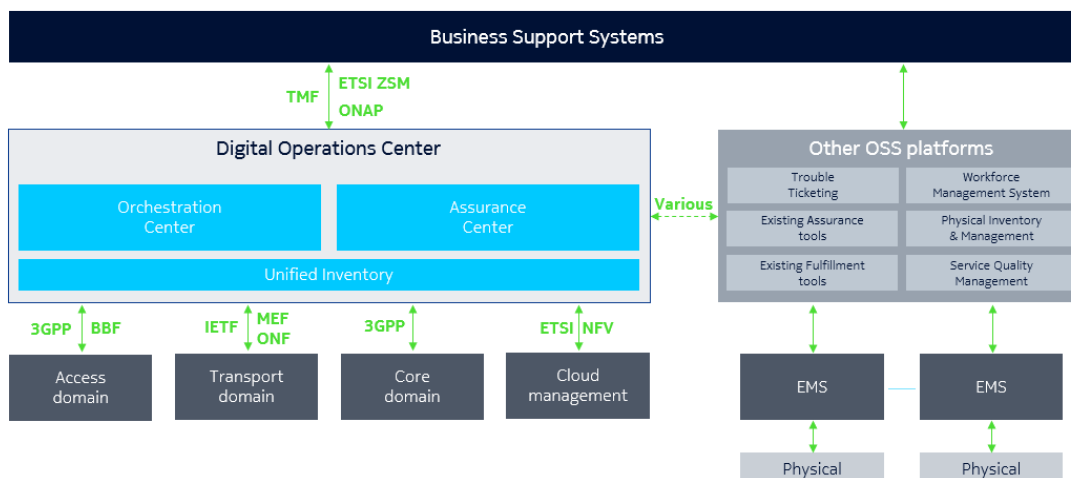
Digital Operations Center has extensive APIs to other systems – both north-bound (analytics, order management, BSS) and south-bound (domain controllers, 3rd parties, etc.)

Nokia supports a wide range of standards including most of the TMF suite of APIs, the ETSI Network Slicing model, MEF Sonata and Legato. They also have an Open SDK and a library of 1000+ integrations to northbound, southbound as well as east/westbound systems off-the-shelf. Presumably these are from older system, adapted to Digital Operations Center. An SDK is available to speed and simplify development, testing and deployment.

**Figure 3: Illustration of Digital Operations Center and Interfaces**

## Digital Operations Center in an operator environment

Supporting standards alignment at all levels



Courtesy: Nokia

### ML and Future intelligent operations

Nokia, already a leader in the use of ML and AI in both networking and security, believe that ML and AI will play an increasingly strong role in the closed loop of Digital Operations Center. Some of the most prominent use cases for ML-based AIOps automation include:

- automated actions based on anomaly detection mechanisms.
- preventive SLA adherence based on predictive KPIs and closed loop with orchestration.
- service/slice optimal resource utilization on any cloud by managing policies and capacity based on QoS/QoE profiles.

### Closed Loop Automation

Most readers know that Appledore believes that it is not enough to close the loop; it must be closed properly with the elegant simplicity of a self-regulating control loop. Proper loops demand little or no code development – they simply look for a state/performance change, and make the incremental changes necessary to return the service to conformance with intent. A key tenet is that the original orchestration method should be (re-) used. This is both simpler (no additional code) and better (consistent, proven, inherits all upgrades).

The following quote, from Nokia, confirms that this is how Digital Operations Center operates:

*“Once the service has been delivered successfully, the orchestration engine continues to check for service state changes. The engine will be triggered whenever there is service state change. It calculates the delta between the current and the desired/intended state based on the policies defined and then performs reconfiguration of the service instance to ensure that the desired state is maintained.” -- Nokia Written Response to Appledore*

In summary, Digital Operations Center represents an investment in what is essentially an all-new product. As such it no doubt will have a continued roadmap before it is fully complete, but it also represents a modern, control-theory consistent approach. Beyond its underlying technical features, it is also (per Nokia, above) designed without constraining assumptions regarding the nature of services and, given proper modeling, ought to be able to support whatever innovations our digital future holds.

## MARKET IMPACT

New products are the blade that cuts both ways. While modern and a fresh start they are, almost by definition, limited in proven deployments. And so is the case with Digital Operations Center. Nokia emphasizes that they have a huge installed base of previous generation products to upgrade, and also point to a number of serious PoCs (since their response we know that one more is moving to production).

The table below provides evidence for Nokia’s progress in the CDSO market, specifically those deployments that meet Appledore’s criteria for modern, next-generation and cross-domain service orchestration. According to Nokia, these deployments, of their more than 200, best reflect their market success in true, cross-domain orchestration employing modern automation methods. Note

that the scope of our report and this list omits in-domain orchestration (for example, those entirely in the IP, transport or cloud/datacentre domains).

Nokia, a radio vendor at heart<sup>1</sup>, clearly positions Digital Operations Center for 5G operations and services. Its references in Service Orchestration all relate to 5G contexts. However, as with almost all vendors, a significant proportion of this advanced 5G activity is at a PoC stage.

The company claims 200+ “CSPs and enterprises” supported by its service orchestration and assurance (now “Digital Operations”) portfolio (with at least 75 of those added in the 12 months to end Sept 2021), but we suspect that most of this represents an expanding role in relation to legacy networks.

**Figure 4: Nokia Digital Operations Software Deployments (most pre- Digital Operations Center)**



Source: Nokia

<sup>1</sup> But to be fair, of the major NEPs Nokia has the broadest portfolio (beyond Radio) across access, IP, Optical, & SDWAN, and a relatively independent organization developing NAS software such as Digital Operations Center.

**Figure 5: Nokia CDSO (Digital Operations Center Market Deployments, as of EoY 2021)**

Operator	Service offerings
<b>Telenor Norway / 5G-VINNI project</b>	Nokia provides the service orchestration capabilities on AWS cloud for the European 5G-VINNI project, which has enabled over 30 use case pilots, trials, and experiments in areas of energy, e-health, industry 4.0, media & entertainment, public safety, smart cities, transports & logistics and other industry verticals. All implement various public-center slicing needs.
<b>Lightstorm Telecom, India</b>	Service orchestration, service assurance and unified inventory, deployed on AWS cloud for closed loop automation for Network-as-a-Service (NaaS) platform
<b>PLDT / Smart, Philippines</b>	End to end orchestration of mobile and fixed services with zero-touch provisioning and closed-loop assurance, leveraging virtualization and 5G capabilities.
<b>CSP Canada PoC</b>	Temporary 5G eMBB slice service to expand capacity for video streaming at a stadium event, private 5G eMBB slice service for enterprise customers and 5G eMBB slice service incorporating MOCN for Shared RAN subnet slice.
<b>CSP 1 USA PoC</b>	5G radio automation, 5G radio slice orchestration and 5G core orchestration.
<b>CSP 2 USA PoC</b>	5G eMBB mobile broadband slice for customers, enterprise 5G eMBB slice with QoS profile, consumer premium stadium 5G eMBB slice with RAN resource partitioning and public safety 5G eMBB slice with RAN resource partitioning
<b>CSP Australia PoC</b>	<p><b>In domain Automation (commercial):</b> Nokia is currently delivering domain orchestration for the purpose of the end-to-end VPN service operations and automation on AWS cloud.</p> <p><b>Cross Domain Innovation &amp; Automation:</b> Nokia conducted a PoC which uses Digital Operations Center as composite orchestrator based on ETSI ZSM framework where it builds composite services using services exposed by domain orchestrators, deliver service based on user intent and performs closed loop automation to recover service state when anomalies are detected. The policy engine is used to optimize 5G core network function placement strategy. The PoC also demonstrates how service designers can use DesignHub for declarative modelling to easily build composite services.</p>

Source: Appledore Research & Nokia

## Beyond Software: Pre-integration, templates and operational models

Beyond the capabilities of the Digital Operations Center software itself, Nokia emphasizes a high degree of pre-integration that lowers solution deployment cost, risk and time-to-operations. They do this through:

1. Pre integration with Nokia equipment and domain managers.
2. Support for 3GPP, MEF and TMF standards.
3. Rapid SDK for southbound and northbound integrations.

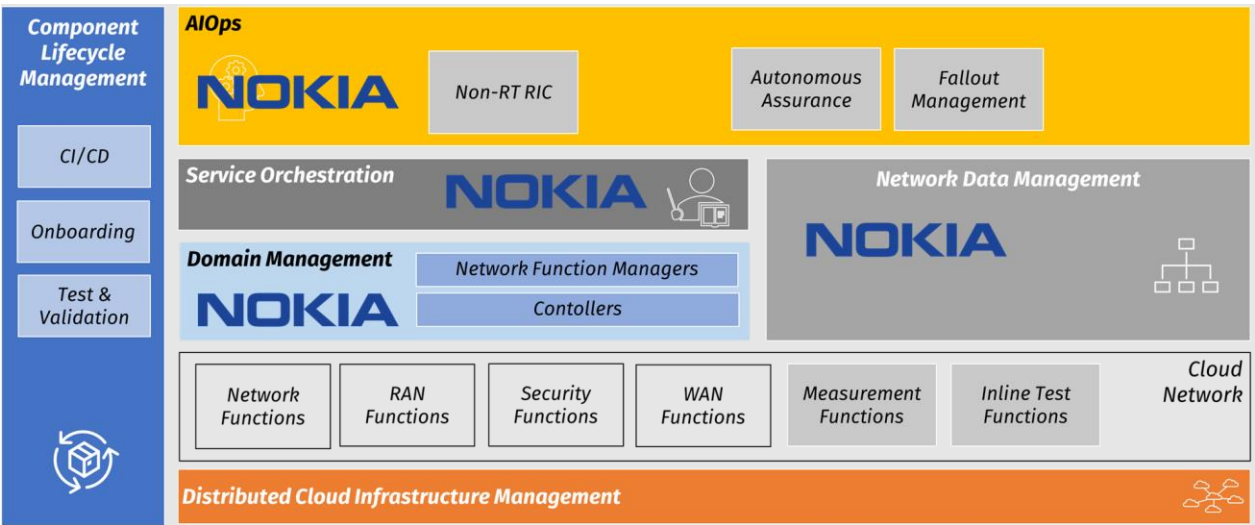
In addition, once the solution is at run-time and services are to be created and deployed, DesignHub facilitates consistency, and therefore eliminates integration that would otherwise have had to be performed.

## APPLEDORE ANALYSIS

In the Appledore Network Automation Software Taxonomy diagram below, Nokia's Digital Operations Center, as a solution, spans three segments. **Orchestration Center**, along with supporting SDKs and development tools, sits squarely in the CDSO segment. **Assurance Center** sits in AIOps, performing closely associated services for Orchestration Center (subset of AIOps, of course). **Unified Inventory** performs again a subset of NDM, concentrating on the dependency map required for cross-domain, loosely coupled, closed loop management.

We also note that the same product, with different models, may be employed in domain orchestration for both transport/IP and cloud-native workload management. Digital Operations Center integrates to external component (AIOps, Network Data Management) from Nokia or others, and interacts with myriad and growing domain controllers/orchestrators. Depending on a specific SP's needs and desires, Orchestration Center may integrate with products competitive to the Assurance Center and Unified Inventory modules.

Figure 6: Nokia Digital Operations on Appledore's NAS Taxonomy



Source: Appledore Research

Appledore supports the key technical capabilities and aspirations embodied in Digital Operations Center. Nokia has invested significantly in “clean sheet” software to support things like intent, closed loop operation, loose coupling and myriad other buzzwords which, in our guidance, may mean the difference between agility/low maintenance going forward and not. These details matter.

On the other hand it is too new to have a good handle on how well it all works, and what may, as with any new product, be missing. The fact that PoCs and early deployments seem to have favorable buzz speaks well.

Nokia has a significant advantage in its customer footprint overall, and particularly in its strength in domain management. Compared to other large NEPs they have a strong portfolio of self-managing domain controllers across SDN, SDWAN, RAN, SON (which we place in AIOps) and cloud management. All provide potential opportunities for Nokia to up-sell to Digital Operations Center. That said, leveraging these demands that other business units tell the bigger story – which was explicitly de-emphasized in Nokia’s most recent re-organization with endeavored to bring focus and accountability to individual units – a good thing no doubt, with some consequences.

100 contract expansions in 12 months suggests a high level of roll-through from existing business – a sign of strong customer relationships. Many existing customers may see adding Nokia’s Cross-Domain Service Orchestration as a low-risk contract expansion option as they experiment with 5G use cases and move toward higher levels of automation and innovation. And there is a lot to like here: the combination of API and UI, for example, use of templates, and the integration with assurance to form closed loop.

The global customer base, even allowing for the amount of PoC-level projects, is noteworthy.

## SWOT

### Strengths

- Strong customer base
- Strong domain controllers in Nokia portfolio
- Modern platform as of 2021
- Solid technical support for intent, closed loop
- Pre-integration with Nokia domains and network functions
- High degree of standards compliance

### Weaknesses

- New product with very few cross domain deployments to date
- NEP/proprietary reputation to overcome
- Packaging suggests a more monolithic solution (per Nokia, untrue)

### Opportunities

- Leverage base and major waves of slicing and NaaS - both strengths
- Leverage Nokia's complete family of domain controllers/orchestrators (SDN,SDWAN,RAN,SON)

### Threats

- How much of the market is already or being locked up by competitors who arrived before Nokia's new solution?
- Many direct competitors (NEPs), ISVs, IT giants and disruptors entering this market.

## SUMMARY

Digital Operations Center is Nokia's all-new entry into next-generation, cross-domain, service orchestration. Unlike many others, Nokia is explicit about the modules that, in its opinion, are required to deploy class-leading, highly automated, closed loop management of services, including network slices. These three modules are all part of their "Digital Operations Center" but may be deployed individually, and may be matched with 3<sup>rd</sup> party products (that provide all the requisite features). These are Orchestration Center, Assurance Center and Unified Inventory.

As a new product Nokia's proven, commercial deployments are few. But they have a huge base of previous generation products to migrate forward, an impressive list of serious PoCs and trials, and many deployments of Nokia's domain-automation products (e.g.; NSP) that may, in the next step, be aggregated by Digital Operations Center. We believe that both potential buyers and Nokia should strongly consider this story fully.

Digital Operations Center checks all of the boxes that Appledore suggests for best practices in automation (more generally) and closed-loop automation in particular. It is intent based, specifically provides for the complex recursions that will occur as intent is negotiated across domains, supports many standards, and offers rapid development SDKs.



Appledore believe that suppliers with broad portfolios such as Nokia have both a great asset base, and a great challenge: to convey how these many piece-parts fit together. Everything we see says that with this product, Nokia is in fact telling the entire story, yet in doing so it may be overwhelming or appear “monolithic” and closed. We investigated both and feel confident that it is neither.

We look forward to seeing how Digital Operations Center performs, and transforms operations, in significant deployments as soon as they may be discussed.



**Insight and analysis for telecom transformation.**

 @AppledoreVision

 Appledore Research

[www.appledoreresearch.com](http://www.appledoreresearch.com)

[info@appledore.org](mailto:info@appledore.org)

+1 603 969 2125

44 Summer Street Dover, NH. 03820, USA

© Appledore Research LLC 2022.

