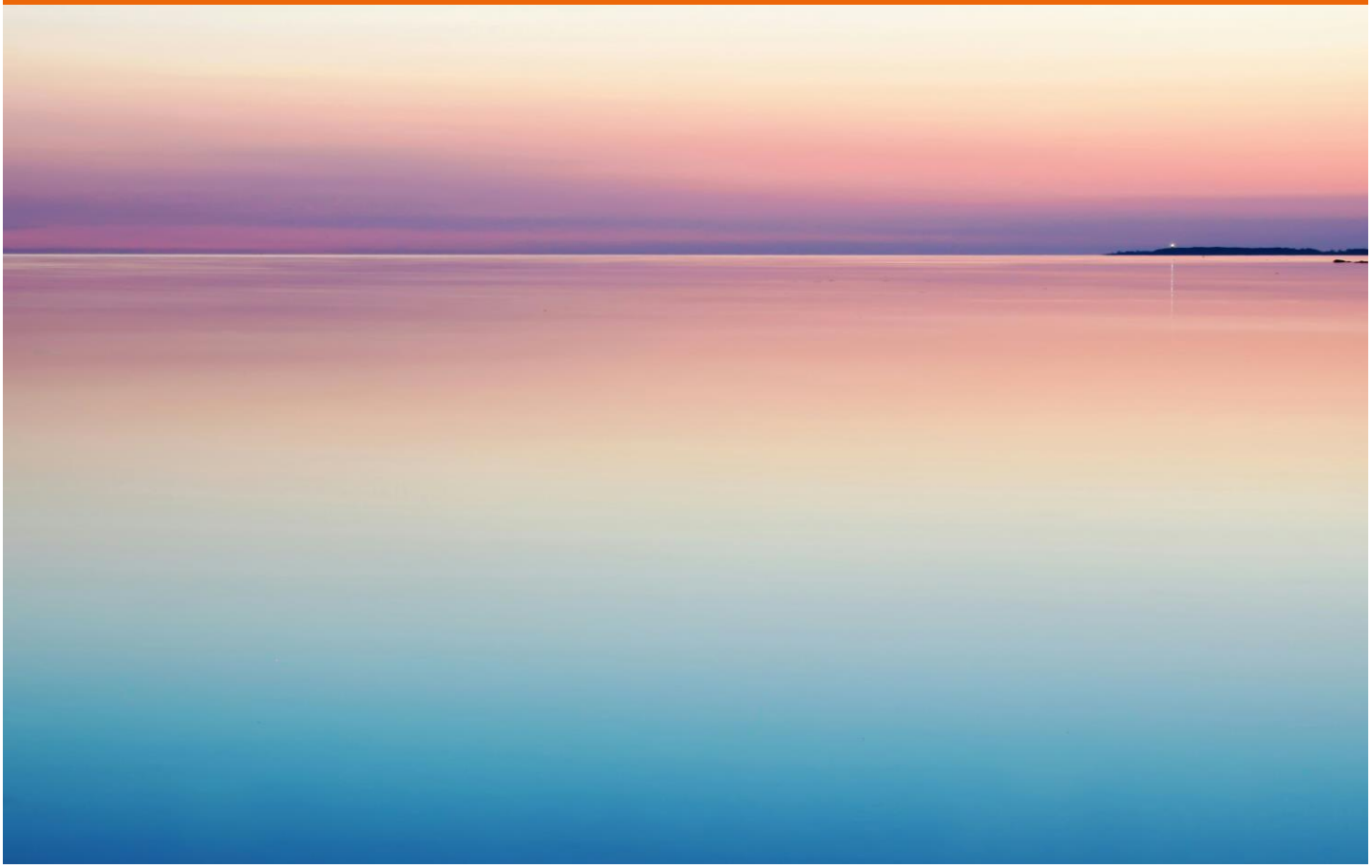
Market Share

July 2024

Leading Suppliers in Network Automation Software

Year-Over-Year Growth Stagnates, Reflecting a Flat Market Performance

Author: Patrick Kelly, Grant Lenahan, Francis Haysom, Robert Curran



www.appledoreresearch.com

Appledore RESEARCH

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

Tel: +1 603 969 2125 • Email: info@appledorerg.com• www.appledoreresearch.com

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: 11 July 2024

Cover image: Photo by Harli Marten on Unsplash

TABLE OF CONTENTS

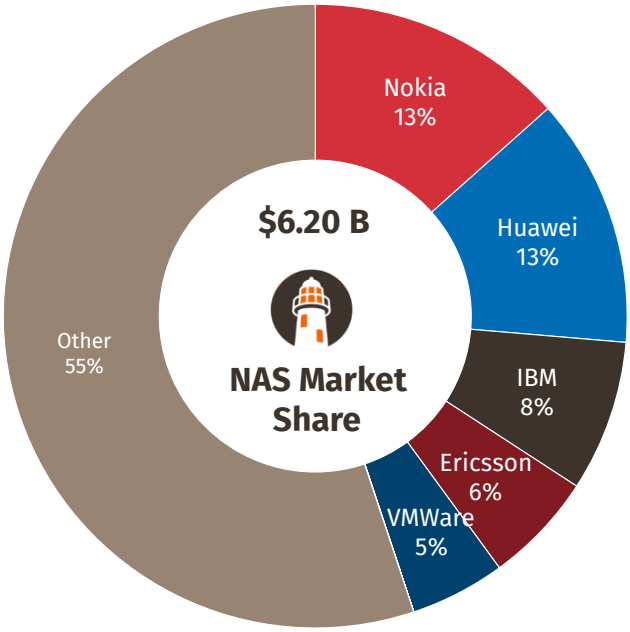
Table of Figures

Executive Summary

The global spend on Network Automation Software (NAS) in 2023 was **US$6.20 billion.**

In 2023, global spending on Network Automation Software (NAS) reached US$6.20 billion. Despite substantial growth from 2021 to 2022, driven by post-pandemic spending and increased data management vendor activity in telecom, our analysis shows that the market remained essentially flat from 2022 to 2023, with $6.20 billion in 2023 compared to $6.21 billion in 2022.

Figure 1: Network Automation Software Market by Supplier, 2023



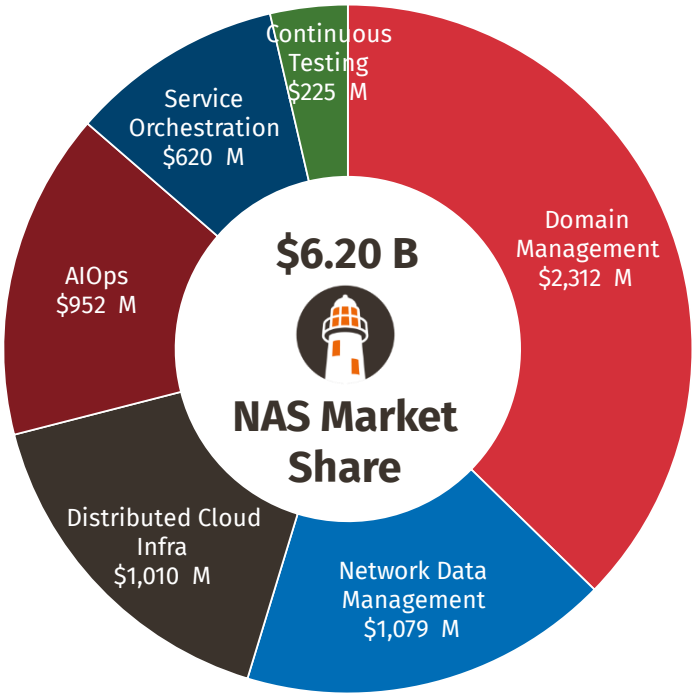
Source: Appledore Research

The top three companies account for 34% of the total market, a decrease from 38% in 2022. **Nokia** and **Huawei** benefit from having products in nearly every segment, while **IBM**'s third-place position reflects the combined value of its **Red Hat** and IBM businesses (with subsegment market shares and commentary provided for clarity). **Ericsson** and **VMware** (Broadcom) fill out our top five NAS vendors.

Beyond the top five, a group that includes **Amdocs, Ciena, Cisco, HPE, Netcracker, Oracle** and others collectively account for over half (55%) of market spend, consistent with our 2022 analysis.

In 2023, AIOps emerged as the standout NAS segment with a 29.9% year-on-year growth. AI continues to hold the potential for a profound future impact on CSPs' operations. Accordingly, this report includes an in-depth analysis of the major players in the AIOps segment.

Figure 2: Network Automation Software Market by Category, 2023



Source: Appledore Research

The segments of this market are **AIOps**, **Service Orchestration**, **Network Data Management, Domain Orchestration, Distributed Cloud Infrastructure Management** and **Continuous Testing**. (Appledore's overall telco software market taxonomy includes a separate next-gen-BSS segment **Digital Enablement**, although we break this out in separate market share report.)

Domain Management ($2.31B) remains the largest single segment but continues its steady decline as a proportion of overall spend (37% in 2023 vs 40% in 2022).

Network Data Management remains comparable to last year's estimated market size and also to **Distributed Cloud Infrastructure Management** at just over $1.0B in network automation software. Both are still just slightly larger than **AIOps** ($952M). **Service Orchestration** spending fell slightly year-on-year ($620M vs $636M). The smallest segment we track, **Continuous Testing** ($225M) saw modest (but still the second highest) growth rate over 2022's figure.

Two equipment vendors lead the NAS market: **Nokia** (13%) and **Huawei** (13%). These two lead **IBM** (8%) and **Ericsson** (6%) and **VMware** (5%).

Key takeaways from this analysis are:

- Despite positive indicators in 2022, the pace of investment in next-gen operational support systems significantly slowed in 2023.

- The investment agenda at telcos has tightened, focusing on high-impact, low-investment areas such as reducing energy draw and quick wins from customer experience improvements.
- NAS, like all network software, remains tied to the network hardware investment cycle. Software spend is often budgeted as a percentage of capital spend on network hardware, and when that decreases as rollouts conclude, telcos expect a macro-level reduction in software investment, particularly in 5G and fixed networks.
- Major acquisitions, which take time to finalize, may have created some uncertainty for CSPs in their investment plans, leading to temporary delays spanning multiple quarters.
- CSPs are struggling with taking successful network automation proofs-of-concept into production, as large-scale automation benefits often require challenging organizational changes.
- Ironically, the rise of GenAI has renewed interest in older AI/ML applications. While many GenAI possibilities remain speculative, practical applications of AI/ML in networking, a trend for at least five years, are now mainstream and worthy of increased investment.

Nonetheless, we remain optimistic about the outlook for NAS. The technologies are already mature or rapidly maturing, aligning with telcos' strategic goals of lowering costs, increasing agility, and making smarter use of energy and personnel. Numerous examples showcase the potential achievements. The pressure on telcos to present credible plans for improved performance persists. While NAS spending may have flattened for now, it remains the only realistic solution for telcos to meet their strategic objectives.

Network Automation Software Market

Definition

"Network Automation Software", is software that automates the qualification, test, deployment, healing, scaling, monitoring, and intelligent management of networks and services, from pre-deployment through turn-down. Typically, it aspires, depending on segment, to both multi-vendor support and support for autonomy, cloud-native, and CI/CD/CT, and has taken concrete steps in those directions. This contrasts with the spend that we *exclude* from our NAS market share - legacy software that is single vendor and does not implement or directly support intent based autonomy. We acknowledge that spend on such legacy systems still represents the major portion of overall "OSS" spend – but our goal is precisely to shine the spotlight on the new and progressive, especially as the basis for that spend does not rely on strict conventional demarcations of fulfilment, inventory, assurance.

This includes:

- Orchestration, policy, analytics (including AI/ML), data management, domain controllers such as SON and SDN-C/SDWAN.
- The myriad niche products that turn up, down, scale out, reposition, optimize, test, and configure CNFs and services that span chains for CNFs (and, of course, PNFs).

This definition does *not* include:

- The software and hardware **network functions** themselves (routers, radios, optics, EPCs, application servers, etc.).
- The underlying **hardware platforms**, whether datacenter X86 or special-purpose chip based.
- The virtualization **middleware** such as hypervisors and related software.

It is worth noting that many processes will increasingly incorporate ML and then AI into them; therefore ML/AI is not a category on its own, but a growing component of many segments, especially domain orchestration, intelligent controllers, service orchestration, and of course, AIOps. It may be embedded, it may be standalone (in AIOps).

Appledore segments the market for network automation software into the following categories:

- **Artificial Intelligence Operations** ("AIOps") – the applications that use network (and other) data to drive decisions and processes.
- **Service Orchestration** – end-to-end control of network services and functions.
- **Domain Management** – largely, the classical "network-facing" functions.
- **Distributed Cloud Infrastructure** – software used to automate and optimize network inventory, place workloads.
- **Network Data Management** – collection, storage, presentation of network data of all kinds.

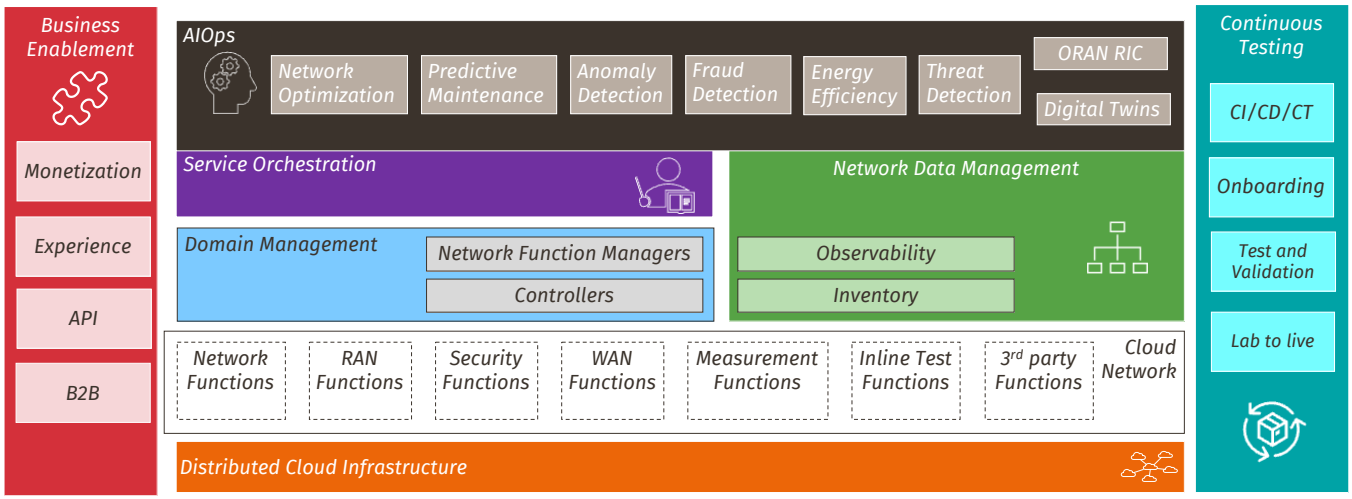
- **Continuous Testing** (CT) formerly LCM – software for automation of test, validation, onboarding and retirement of (software-ized) network functions.

Spending on Cloud-native Network Functions is largely excluded from this market share analysis.

Our wider research looks at market share in an additional segment, **Digital Enablement,** the software that engages with and exposes the cloud software network to others via APIs. Digital Enablement has its own market share and forecast reports, here.

In this market share report, we size six of these segments. For clarity, the high-level, relative positioning of the segments is illustrated in Figure 3: Appledore Telecom Network Automation Market Taxonomy.

Figure 3: Appledore Telecom Network Automation Market Taxonomy



Source: Appledore Research

Appledore is taking a forward-looking view of how the market will evolve. Our market segmentation of NAS reflects this. We acknowledge that much of the software procured by telcos in 2023 will have been procured as line items using traditional terminology such as inventory management, fulfillment systems, probe software or workflow applications, even where such line items are purchased in support of a truly next-gen strategy.

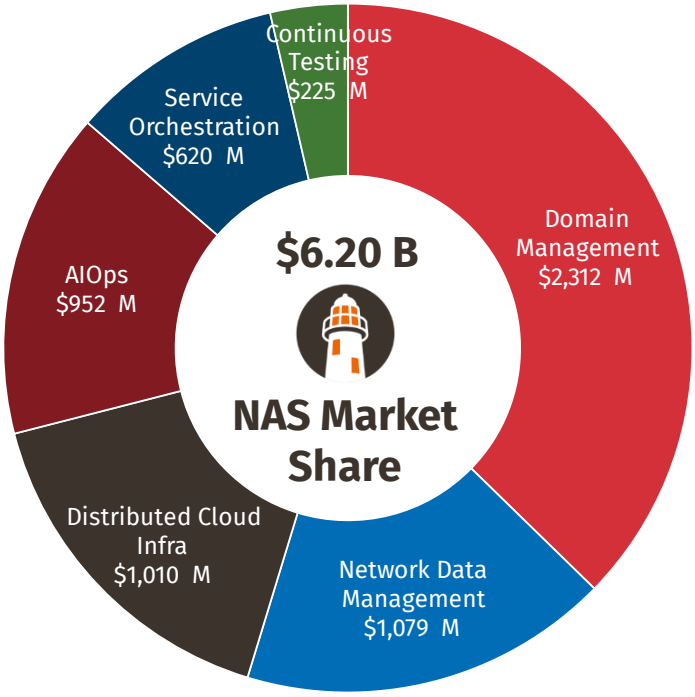
Our assessments are based on a combination of hard financials (where available), and many hours of briefings and conversations with vendors and operators throughout the year. There is always a degree of professional interpretation and estimation.

Market Size by Segment

The global spend on Network Automation Software (NAS) in 2023 was **US$6.20 billion.**

While we saw significant growth from 2021 to 2022 (supported in part by both post-pandemic spend and an influx of data management vendor activity in telecom), by our analysis 2022 to 2023 is essentially flat: $6.20B in 2023 vs $6.21B in 2022. A slowdown in network buildouts (especially in 5G) is one significant factor that has led to headwinds for NAS in 2023.

Figure 4: Network Automation Software Market by Category, 2023



Source: Appledore Research

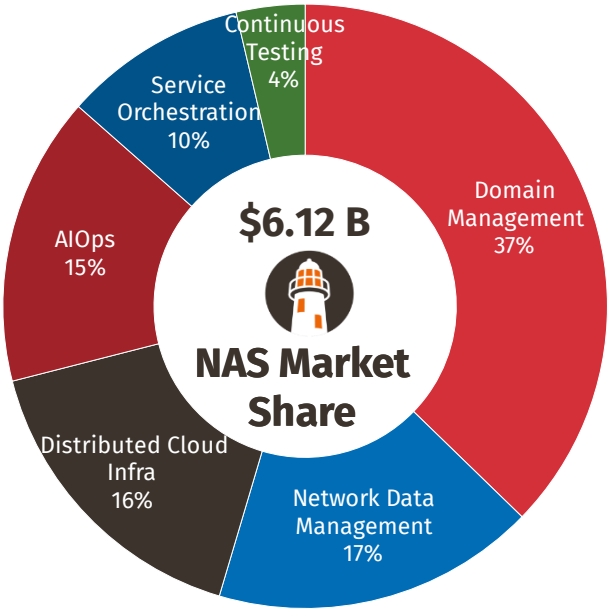
The segments of this market are **AIOps**, **Service Orchestration**, **Network Data Management, Domain Orchestration, Distributed Cloud Infrastructure Management** and **Continuous Testing**. (Appledore's overall telco software market taxonomy includes a separate next-gen-BSS segment **Digital Enablement**, although we break this out in separate market share report.)

Domain Management ($2.31B) remains the largest single segment but continues its steady decline in both absolute size and as a proportion of overall spend (37% in 2023 vs 40% in 2022). Our belief is that Domain Management provides a foundation that can be built upon by the other segments – therefore it dominates early, but other segments then grow proportionally, orchestrating across domains, adding AIOps to domain and cross-domain orchestration, and other advanced functions that depend first on the existence of autonomous domains. We also believe that the domain management market was disproportionately hurt by the pullback in 5G deployment spend – with which it will go hand-in-glove.

Network Data Management remains comparable to last year's estimated market size and also to **Distributed Cloud Infrastructure Management** at just over $1.0B in network automation software. Both are still just slightly larger than **AIOps** ($952M). **Service Orchestration** spending fell slightly year-on-year ($620M vs $636M). The smallest segment we track, **Continuous Testing** ($225M) saw modest (but still the second highest) growth rate over 2022's figure.

In 2023, it was **AIOps** that was the standout NAS segment in terms of growth (+29.9% year-on-year). AI remains the technology with arguably the most profound future impact on CSPs' current mode of operations. Consequently, in this report we offer a deeper dive into what the major players in the AIOps segment are doing.

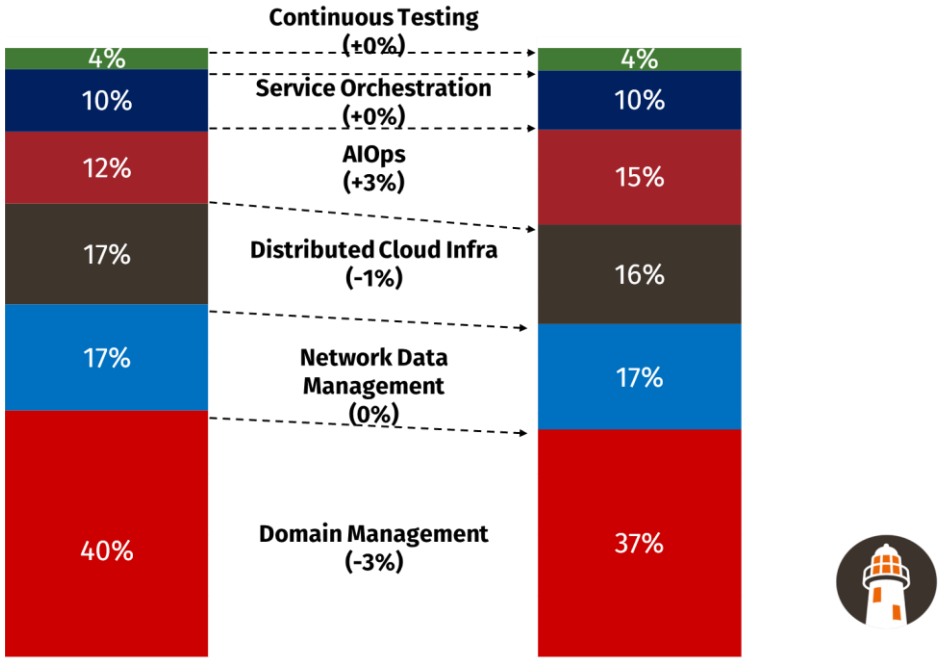
Figure 5: NAS Segments by proportion of total market, 2023



Source: Appledore Research

The change in the proportion of NAS market per segment is illustrated in Figure 6:

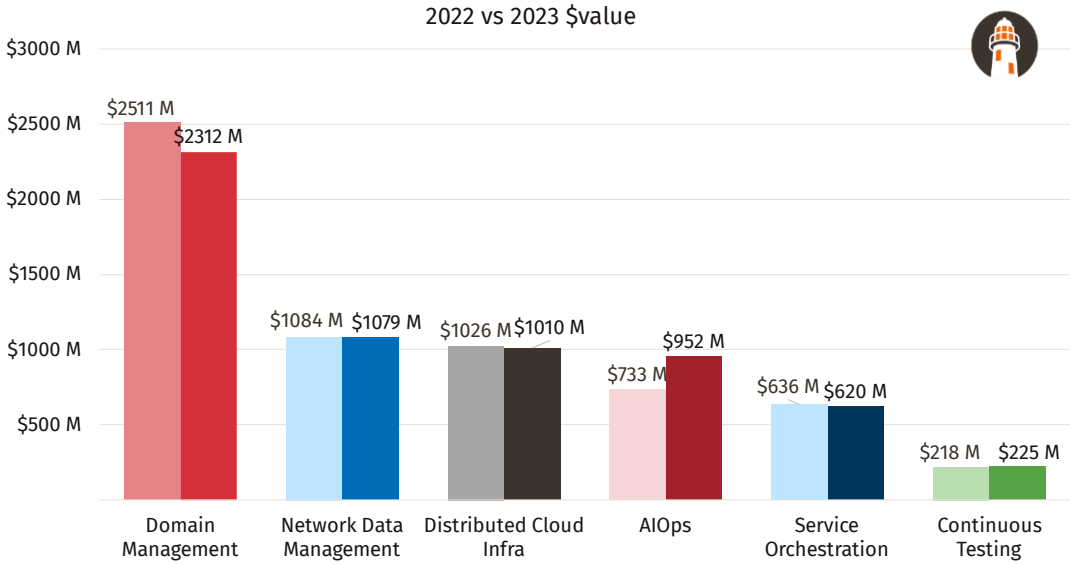
Figure 6: Change in Proportion of overall NAS market by Segment, 2022 vs 2023



Source: Appledore Research

The following analysis shows our 2023 segment spend totals by segment, compared with our 2022 figures (rightmost columns are 2023):

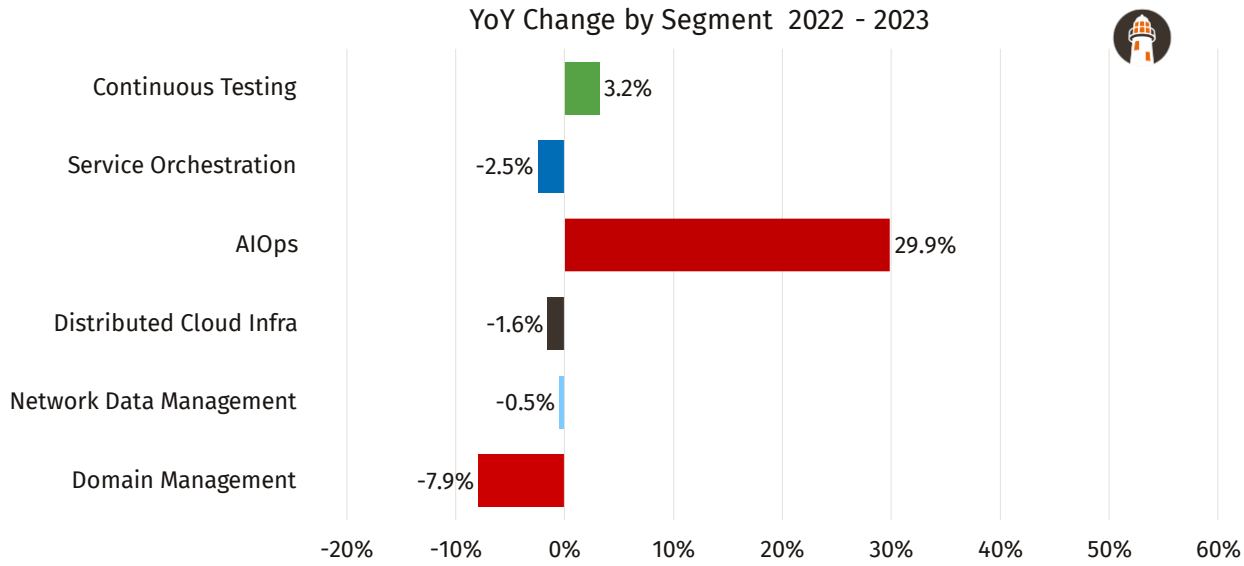
Figure 7: Segments by Value, 2022 vs 2023



Source: Appledore Research

The growth rates per segment are as follows:

Figure 8: YoY Change by Segment, 2022-2023



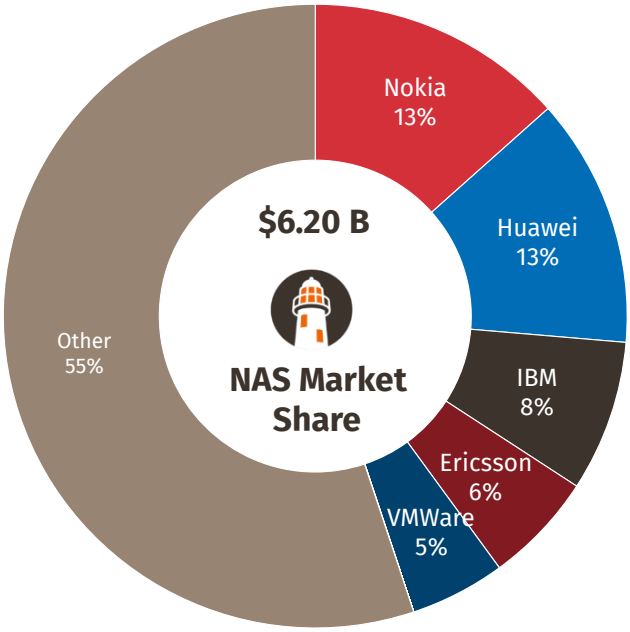
Source: Appledore Research

We discuss the relative growth rates in each segment's detailed analysis below.

Vendor Market Share

Two equipment vendors lead the NAS market: **Nokia** (13%) and **Huawei** (13%). These two lead **IBM** (8%) and **Ericsson** (6%) and **VMware** (5%).

Figure 9: Network Automation Software Market by Supplier, 2023



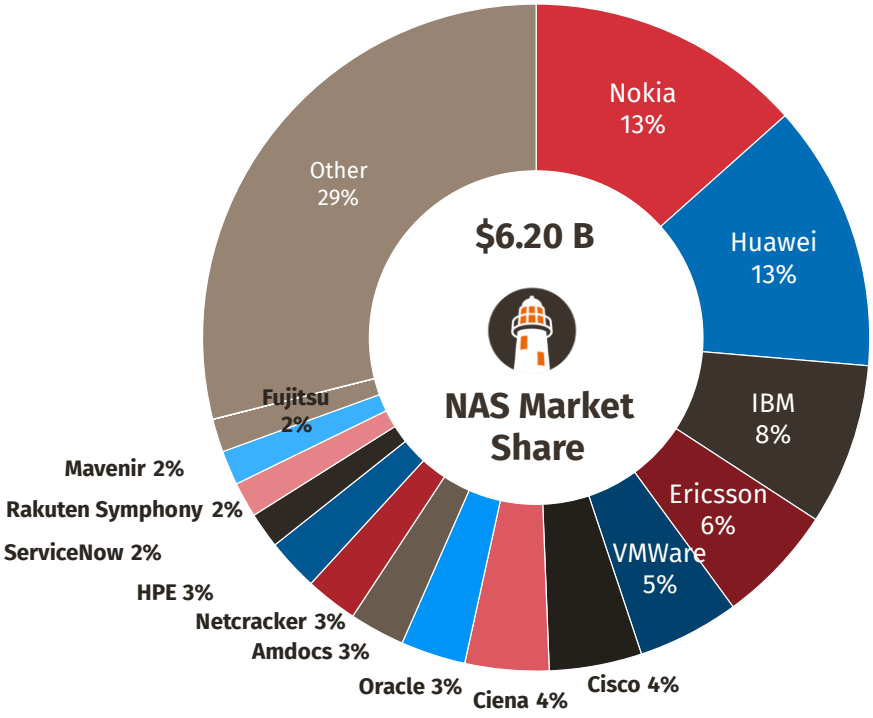
Source: Appledore Research

The top three account for 34% of the total market (down from 38% in 2022). Nokia and Huawei both benefit, vs other large NEPs, from having product products in nearly every segment. **IBM's** third place position reflects the combined value of its Red Hat and IBM business. (For clarity, we break these out in subsegment market shares and commentary). **Ericsson** and **VMware** round out our NAS overall Top 5 leaderboard.

Beyond the top five, a group that includes **Amdocs, Ciena, Netcracker, Oracle, Cisco**, and **HPE** and others collectively account for over half (55%) of market spend, consistent with our 2022 analysis.

Expanding the analysis to companies earning more than $100m from sales of NAS illustrates the wide range of major-name vendors active in this market:

Figure 10: Leading Vendors in NAS 2023



Source: Appledore Research

Market Outlook

Despite the flat growth rate for 2023, we remain optimistic about the outlook for NAS. The technologies are already mature or are maturing very fast. The benefits are exactly aligned with what telcos' strategies say they want: lower costs, greater agility, smarter use of energy and people. NAS is also essential to manage the complexity of new technologies such as cloudified 5G RANs and avoid *increasing* costs. There are a growing number of examples of what can be achieved. There is no let-up in the pressure on telcos to demonstrate credible plans for an uptick in their fortunes.

For now, NAS spend may have flattened, but it remains the only realistic way for telcos to address their strategic aims.

Domain Management

Definition

Domain management performs four, previously distinct, functions on a single well-defined technology domain:

1. Fulfillment/provisioning (Instantiation)
2. Assurance (Self-healing)
3. Capacity Management (Self-scaling)
4. The dynamic, real-time directory of the technology domain assets (inventory) and of their state

This segment includes technology-specific smart controllers/orchestrators, as well as the logical evolution of older Element Management Systems. Distinct domain systems exist because the technologies are vastly different and require specialized knowledge to build. For example, a, SDN controller and a Self-Optimizing RAN controller are radically different in implementation. For this market share we omit non-evolved EMS type products that do not sufficiently meet the standard for being a next generation domain automation platform.

Included in this segment are:

- SDN Controllers.
- SDWAN Controllers (SDWAN edge VNFs or appliances are excluded).
- SDWAN Edge automation “intelligence”. For example, PDF/PEF (policy decision and execution functions). (SDWAN edge VNFs or appliances are excluded). SDWAN edges represents a difficult categorization decision, since the edge (effectively a VNF) and the controller are nearly inseparable.
- RAN Managers and Open RAN managers (SOMs).
- SON systems, where the SON system is primarily single vendor and closely associated with equipment. (If they are abstracted from equipment and truly multi-vendor, they are counted in the AIOps segment)
- Optical Network Controllers.
- Security function controllers (e.g.: for SASE/SDWAN v-firewall etc.).

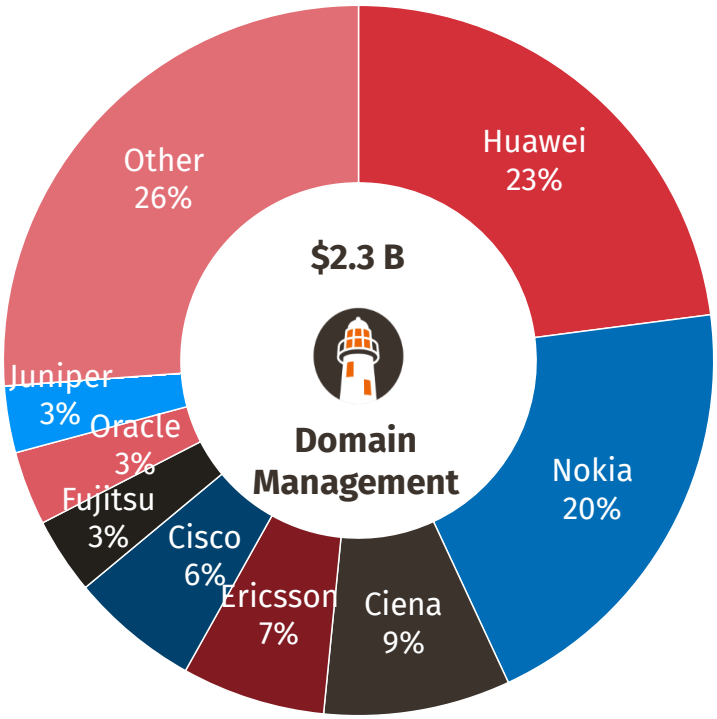
Note that (cross-domain) Service Orchestration has its own segment.

Market Size and Vendor Share

Appledore estimates that the market for Domain Management automation software was $2.36B in 2023 – the largest segment by far, accounting for some 37% of the total NAS market in 2023.

The leading vendors in Domain Management are **Huawei** (23%), **Nokia** (20%), **Ciena** (9%), **Ericsson** (7%) and **Cisco** (6%). A clutch of vendors trail them with ~3%: **Fujitsu, Oracle, Juniper** and others.

Figure 11: Appledore Domain Management Market, 2023



Source: Appledore Research

The commercial market in Domain Management is dominated by existing Network Equipment suppliers. Domain controllers are typically bundled and sold with infrastructure today, both for CNFs and PNFs. That said we are beginning to see the rise of multi-vendor and ISVs in this segment.

Readers should note that suppliers with broad portfolios (SDWAN, optics, routers, 5G, etc.) participate in many more domain segments and consequently have a much larger domain management TAM. Since Domain Management remains the single largest segment in NAS, by far, this has a significant impact on who leads both within Domain Management and across the entire NAS market.

In Domain Management market share, **Huawei** tops our 2023 analysis, followed closely by **Nokia**.

Huawei has a strong showing based not only on its sheer global size, but also on the breadth of its network function portfolio, which also includes RANs, IP, SDWAN and Broadband Access. Like Nokia,

Huawei emphasizes self-managing domains in its autonomous driving networks (ADN) architecture, thereby emphasizing the evolution of EMSs to true domain controllers/orchestrators. Unlike Nokia, we see less evidence of Huawei domain automation software being used extensively with third parties, although this may be more a market situation than a reflection on their capabilities. Huawei, unlike most western suppliers, did not see a 5G market downturn.

Nokia scores the second spot, based on its broad product line of SDWAN/SASE, Automated Security, SDN/IP, Optical, 4G/5G, Broadband Access and cloud management, all of which have strong domain control systems that implement local automation and control loops. Particularly strong is Nokia's business in IP and Optical, where NSP and its related optical management products are leaders in the market. Nokia has long promoted automation within domains, harking back to products that preceded Nokia. Nokia's position has been impacted by this year's reduced 5G deployments, and by weaker market performance of its Nuage unit in the SDWAN segment.

Ciena, like Cisco and Juniper**,** is particularly strong in its core domains (Navigator NCS, previously "MCP"), in this case optical gear, but with a growing IP portfolio and some domain-focussed capabilities from its Blue Planet products.

Ericsson is also a leading player overall but holds a much smaller domain management market share due to its lack of IP, optical and SDWAN domain network functions. On the other hand, its RAN management is among the strongest, reflecting a large base of Ericsson customers and its strength in 5G, especially in high labor-rate regions.

Cisco is also a strong player in its core domains, namely IP routers (again both virtualized and physical) and in SDWAN. Sometimes overlooked, Cisco, through its acquisitions of Viptela and Meraki, is among the strongest SDWAN players, leveraging its router base (on which SDWAN can be a feature set) and enterprise relationships (sales channel, pressuring CSPs to sell Cisco SDWAN offerings).

Fujitsu primarily plays in optical gear and 4G/5G radio, with a strong, but embryonic target in Open RAN. In domain management they are notable for management of multi-vendor optical networks (Open ROADM).

Oracle's showing in the top 10 vendors in Domain Management is based mainly on its SD-WAN business (the original Talari acquisition).

Juniper has a particularly aggressive play in the automation of IP networks, but readers should note a few caveats: 1) much of their market is enterprise and outside this analysis; 2) much of their new software is in areas such as AIOps and Continuous Test – while applied primarily to the IP domain.

(Note that in our analysis for the domain management, we assign SON as an **AIOps** function, rather than domain management. This is in part because mobile radio access network optimization has emerged as one of the single largest use cases within AIOps, from our discussions.)

Segment Outlook

A tenet of Appledore's NAS taxonomy, as well as the ETSI and TM Forum reference architectures, is that domains are autonomic and self-managing. A similar tenet of control theory is that control loops should operate at the lowest level practicable, and then be aggregated at a higher layer. Domain automation solutions, which rely on a core of orchestration, effect this distributed, modular architecture.

There is also a strong affinity for domain automation solutions to be provided by experts in that particular technology. Optical experts understand how to manage optics. Radio experts understand how to manage radio, etc. The domain management market is the largest single segment and led the way in deployments. This makes perfect sense: you need domains to exist before you can work across domains, and with a more constrained scope the complexity of automation is lower and often better understood. There are a growing number of examples of proven success with cloud-native datacenter managers, and IP optical managers that can calculate routes and automatically heal them when necessary. Significant progress is being made across domains.

Being technology specific, there are many sub-segments of Domain Management. The following is a representative summary of what is included in this segment. We do not include traditional proprietary EMSes in this segment nor any "controllers" that do not effect proper automation, including aspects of a closed loop and a realistic roadmap forward. (similar caveats are used for all segments)

- SDN/IP Managers / Controllers
- Optical Managers (including Open ROADM)
- SDWAN controllers (often proprietary, but effecting highly advanced automation in both security, traffic steering and configuration)
- RAN Managers for 5G/4G
- Open RAN SMO (Service Management and Orchestration)
- Access Network Managers (PON/FTTX)
- Many other technologies within the network

Distributed Cloud Infrastructure Management

Definition

Distributed Cloud Infrastructure Management measures that portion of datacenter software that automates the placement, tracking, monitoring, and overall Lifecycle Management of virtualized workloads. Below we specify what is included and excluded from the totality of datacenter investment (including large, small, and edge) on which CNFs and VNFs are placed and run.

Included in this market share is software that automates the monitoring, real-time inventory/availability, places workloads, places networking connections, performs analytics and optimizes utilization etc. This includes ETSI MANO VIM and cloud-native management systems.

Excluded from this market share are:

- Hardware (computer, memory, storage, networking)
- Software that implements the Virtualization "plumbing" such as VMs, hypervisors, KVM, Kubernetes etc.

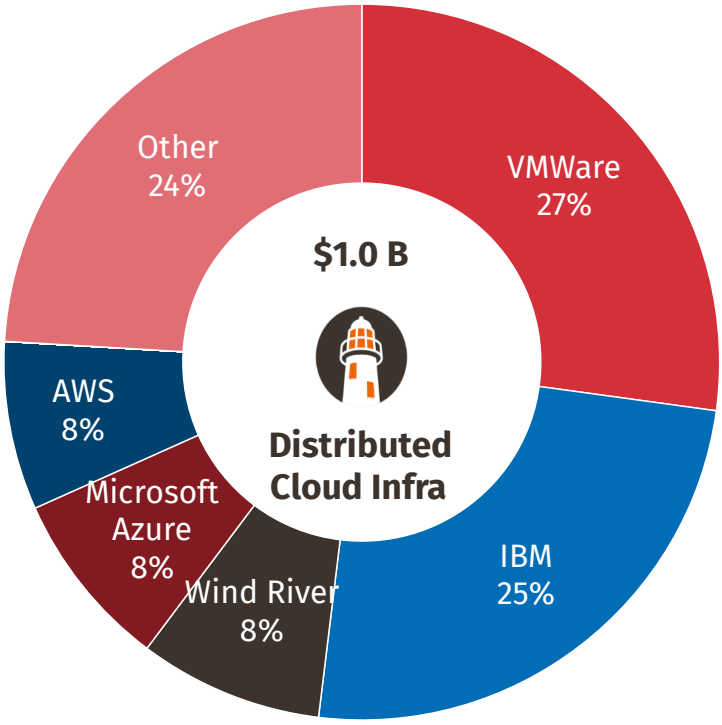
Appledore's objective is to distinguish between the control (management/automation) software for network workloads, and the runtime VMs, containers etc. that are pre-existing and shared resources.

We place public cloud solutions such as **Azure**, **Google Cloud Platform** and **AWS** within this segment in the cases where they support in-production, live network traffic for telcos (still an embryonic market, but expected to grow rapidly, driven in part by edge). We apply estimation methods to separate the various segments of public cloud to assign the appropriate revenue figure.

Market Size and Vendor Share

Appledore estimates that the Distributed Cloud Infrastructure Management (DCIM) market segment represented **US$1.0 billion i**n 2023 (effectively flat compared to 2022).

Figure 12: Distributed Cloud Infrastructure Management Market, 2023



Source: Appledore Research

This market segment might reasonably be considered as "mature" at least for now, with all vendors within 1-2% of where they were in 2022. **VMware** and **IBM (Red Hat)** are the clear market leaders, with over half the total market between them, and ahead of the stable trio of **Wind River** (8%), **Azure** and **AWS** (all on 8%).

VMware remains the leading player in virtualization, with mature, proven VM technology. Networks are still transitioning to truly cloud native. Many networks and the operational systems that support them are still reliant on virtualization, where VMware is strongest. VMware has historically invested significantly in the management functions that support its VMs (the DCI itself) while at the same time shifting its focus toward cloud-native, containerized operations. VMware has also invested in new cloud-native orchestration technology (Telco Cloud Automation) and in support for hybrid cloud (multi-vendor/multi-environment) operations. The acquisition of VMWare by Broadcom at the end of 2023, is not reflected in the market share numbers. It is still too early to assess the actual effect this will have in future. However, the associated changes in commercial models, and question marks over continued investment may accelerate the process of moving to cloud-native environments, where VMware do not have such a strong differentiation.

IBM with its **Red Hat** division is a leading provider of opensource-based DCI, based on OpenStack, but extended and productized. Red Hat sells with and through several vendors including NEPs and hardware firms. In 2023 this culminated in key partnerships with Nokia to become its primary reference platform for CloudBand brand using Red Hat OpenStack Platform and Red Hat OpenShift. All the NEPs have similar lines of business but differ in implementation. As of 2023, Nokia announced that it was partnering with RedHat for going forward DCI and will gradually shift customers from its internally developed software to RedHat delivered software, with capability input from Nokia.

Wind River has a major focus on support for 5G Cloud RAN and edge applications, based on Wind River's long-term focus on mission critical systems and the far edge. They have several telcos, including one Tier-1 anchor customer, using their solution to support Cloud RAN and Open RAN solutions.

The "big 3" Public Cloud players (**Microsoft Azure, Google Cloud Platform, Amazon Web Services**), while giants in cloud platforms, are still relatively small in the niche of DCI space (which implies hosting demanding network U-plane workloads such as 5G DUs or similar). It is also worth noting that most such workloads exist at or near the far edge, which breaks the hyperscalers' models of huge datacenter scale and huge economies of multi-tenant scale. Over the past 3 years, they have gone from essentially zero commercial revenues, to showing up on the leader board. **Azure** created its *Nexus* offer within Azure for Operators targeted to network workloads and anchored by AT&T and has not announced its second large CSP customer. In parallel, **AWS** has garnered much attention supporting **Dish Network**, but wider use in networks remains largely in the trial stage without major network deployment. There are no confirmed deployments of demanding network workloads operating in GCP.

Segment Outlook

There is significant market momentum for network elements to be operated as cloud native, modular workloads. Significant progress has been made in cloudified core solutions, and now increasingly in the RAN. However, with the lack of increased monetization from 5G, and the possible industry pause on 5G plans, Appledore anticipate a slowing of growth in DCI in the short term. The movement of Open RAN from trial to large scale deployment is seeing a move away from best of breed solutions to single vendor led procurement. This in turn favours vendors like Red Hat, with strong partnerships an integration with key network vendors.

The hyperscale providers are worth a specific note. These are giant providers of cloud services globally. They are also very large suppliers of public cloud services to telecom. Their revenues in this segment have grown but remain modest. This is because the vast majority of their sales are for normal IT workloads – which does not qualify as NAS. DCI in telecom continues to be mainly delivered as part of a vertically integrated stack, bundled with hardware. In essence retaining the existing network of dedicated network boxes, but with the added complexity of virtualization or container management, and telco specific needs for high availability at the edge. This means that many of the key benefits of cloud do not exist in today's network:

- Optimized operational cost through multi-tenancy
- The requirement for dynamic scaling in response to new services, in what remains a semi-static long term planned network.

Currently many telcos see public cloud as more expensive to private. Appledore expect these firms to grow rapidly, only when (or if) telco truly moves to a network on the cloud rather than on a box, and/or they start delivering truly dynamic/on-demand services that require public cloud scaling.

Network Data Management (NDM)

Definition

The concept of Network Data Management as a distinct category, separate from existing telecom applications was introduced in our 2020 NAS report. It reflects a move (and a need) in the industry for a more data-centric approach to operational systems, one where decision-making is driven by open access to all sources of data and not constrained by data hidden within vertically integrated applications. As a category, it must account for an industry that still largely measures and positions its products against traditional categories like assurance, probe management, inventory, and integrated NMS. In making our assessment we have used data from all these traditional areas and assessed where these systems allow open exposure of data and enable innovative AIOps applications using this data.

This category includes data collection methods as well as the storage, management and structures placed around the resulting shared reference data that is subsequently used by other functions. Ideally, this data will be collected along with context data such as timestamps or associated network or traffic conditions.

NDM specifically includes:

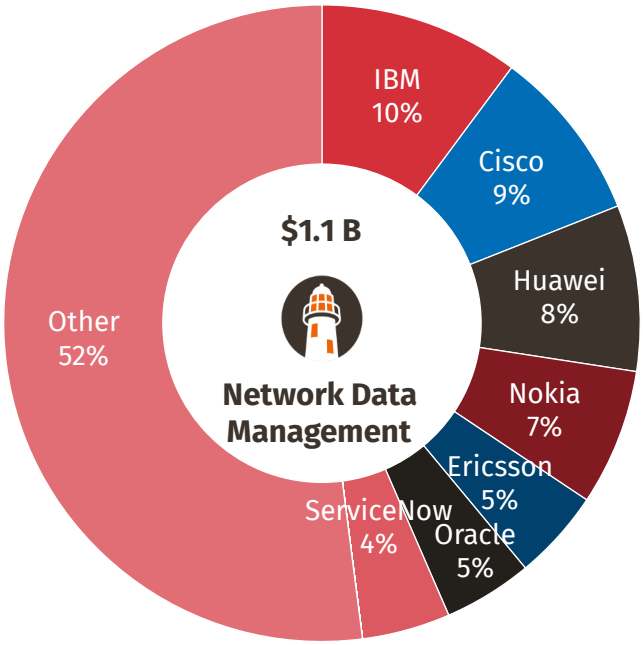
- Data collection software and methods, such as probes, fault collection agents, specialized FTP software, performance data collection agents, streaming data collection software. Linux embedded eBPF, and similar.
- Broad-based, “big data” collection, onboarding, and normalization solutions, for example, Cisco(Splunk). Note that some analytics solutions have both collection and domain-specific analysis capabilities. The domain-specific analytics fall into AIOps.
- Observability solutions
- Data Lakes and query repositories.
- Graph dependency databases that relate users to services, and services to underlying services.
- Service instance inventory.
- Inventory federation products.

Note that we now regard the various applications around product catalogs (product, service, resource catalogs) as part of the Digital Enablement segment (along with areas such as CPQ), rather than network automation software.

Market Size and Vendor Share

Appledore estimates that the market for Network Data Management software was **US$1.1 billion** in 2023 (unchanged from our 2022 analysis).

Figure 13: Network Data Management Market, 2023



Source: Appledore Research

IBM and **Cisco** tie for leadership in this market, but only slightly ahead of **Huawei** and **Nokia**.

Historically, network data management has largely been associated with network data used to support assurance applications, and reflecting this is our market share leader **IBM** with its Netcool pedigree. Network Equipment Providers also feature prominently with **Nokia** and **Huawei** ranking highly in this category with their multi-domain data management across transport and mobile. **Ericsson** also appears with their more focused solutions for mobile and transport. Parts of **Oracle**'s Unified Operations suite fall within in our NDM category. **ServiceNow** also now features in this market, having expanded their business in the telecom network inventory space.

Beyond these leaders, the large proportion (52%) of this market credited to "Other" vendors includes non telco IT enterprise data management solutions. These provide general data management capabilities aligned with IT observability principles. They support real-time sources of data from both networks and from their underpinning IT infrastructure. These vendors provide general data platforms and are not telco specific. Cisco's acquisition of Splunk reflects its wider enterprise position but is important in better positioning them in telco.

Network Inventory is included in the Network Data Management category, in the spirit of all data as a common resource. In our Inventory Management Market Outlook, we estimate that Inventory management is 10% of the NDM market making it worth $100M in 2023. Inventory vendors in our top

NDM vendors include **Nokia, Ciena** and **Ericsson**. These and other inventory vendors have an opportunity in providing a unified topology and network telemetry view of the increasingly dynamic network, supporting service orchestration and closed-loop automation. Profiles exist for most of these CDSO vendors, and may be found here.

Segment Outlook

We believe that non-traditional telecom software vendors (such as IT enterprise data management providers like **Cisco (Splunk)** and **Snowflake** will take an increasing role in data management in telcos as the principles of open data access increasingly dominate. We expect the increasing disaggregation of the data platform from the AIOps applications that sit on top of it. Open exposure of data from the network, including NWDAF interfaces in the mobile core, open IP transport interfaces, standardization of optical transport data interfaces, and Open RAN RIC interfaces to support independent rApps and xApps are all examples of this trend. This trend will be accelerated by the increasing emphasis on cloud native/microservices architectures where Linux/eBPF software telemetry may perform better than existing telemetry approaches. It is also likely to be accelerated by the growing need for disaggregated observability to support automation/autonomy, where real time data is no longer tied to just one operational process, network technology or analytics solution.

This is both an opportunity and a threat to the existing Network Data Management leaders. They will need to decide where their focus should be data platforms or domain expertise.

AIOps

Definition

AIOps includes point tools to improve specific business outcomes in network optimization, anomaly detection, predictive maintenance, network threat detection, and energy efficiency. AIOps is also being deployed as a platform to process structured and unstructured data to gain insights for specific business functions. We also include in this segment data platforms that support home grown AI applications built off data lakes. Key features and functionality of products in this segment include:

- Identifying normal patterns, and therefore abnormalities.
- Identifying threshold crossings and impending crossings.
- Performing RCA, using various methods.
- Learning best practices and automating corrective actions, including guiding human actions – from CSRs to engineers who want more certainty, data and guidance.

From our research, the primary drivers of spend on AIOps are:

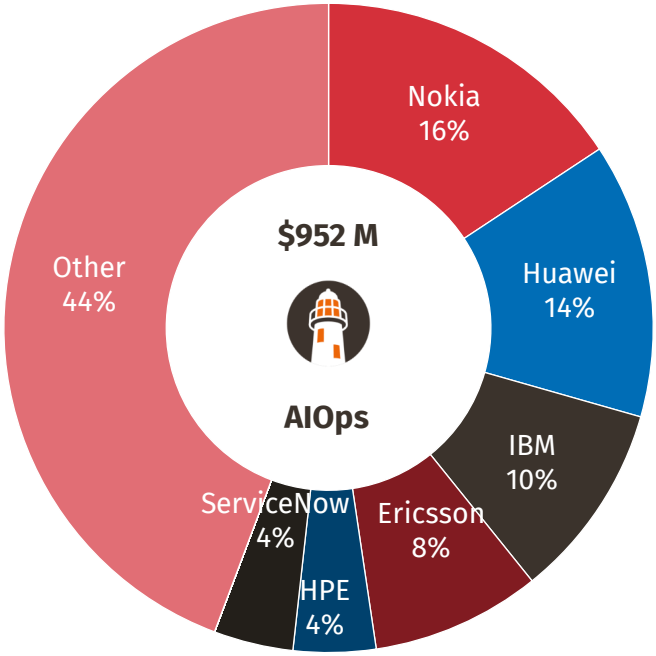
1. Predict future service impacting events.
2. Facilitate automation – primarily closed loop self-healing and -scaling.
3. Offload network complexity from human experts to machines resulting in productive gains.
4. Better understand revenue opportunities and ways to better serve customers and segments.

Pro-actively identify service and customers impacting events, to reduce churn and risk damaging the brand.

Market Size and Vendor Share

In 2023 the AIOps market was worth **$952M.**

Figure 14: AIOps Segment by Vendor, 2023



Source: Appledore Research

The segment is led by **Nokia** (16%), **Huawei** (14%), and **IBM** (10%); driven by their respective expertise in both network and analytics technology. A key component in the AI/ML domain is focused research to predict future network state and performance levels.

A great deal of activity in this segment is focused on network optimization, followed by anomaly detection, and increasingly energy management. This is largely driven by improving the customer experience and a need to improve return on invested capital.

Some of the notable suppliers in this segment outside the top 5 include **Fujitsu, Amdocs, Splunk, Cloudera, Snowflake, ServiceNow, Cisco, Ciena, VMWare, Anritsu, Spirent, Infovista, TEOCO, Databricks, Palantir, Datadog, C3.ai,** and **Dynatrace**. All are used to identify trends, baseline normal operation, identify abnormalities, and correlate events.

Nokia

Nokia's AVA brand has established an early lead in the Telco AI market by offering a complete AI-as-a-Service stack through the cloud. The Cloud and Network Services division houses the assets for analytics and AI, as well as Nokia's digital operations portfolio. All Nokia analytics, insights, AI/ML products, and services are unified under the AVA brand name, which is a family of AI-enabled products and services that leverage Nokia Bell Labs' expertise in data science, telco, and cloud.

With nearly 380 customer deployments across various technology domains and operational areas, Nokia's commercial solutions address challenging problems that CSPs have yet to tackle. Unlike many suppliers in the AIOps market, Nokia has secured commercial contracts and has demonstrated strong business growth. Moreover, the Nokia AVA platform offers a vendor-agnostic solution that works seamlessly with leading cloud platform providers and AI algorithms.

Nokia excels in applying AI to business problems, leveraging high-value data, domain expertise, innovation in using ML algorithms, and massive scaling in cloud compute infrastructure. Its relationships with all the leading cloud platform suppliers further solidify Nokia's position in the market. Notably, Nokia's Bell Lab assets, with its pool of PhDs and data scientists, are often overlooked, despite their significant contributions in tuning and perfecting the algorithms. Combined with Nokia's field and development resources in mobile and fixed network domains, Nokia brings credibility and relevance to solving RAN optimization and network anomalies.

Nokia focuses on high-impact opportunities that help control costs outside the operational domain. As mobile operators' energy consumption is set to increase with the deployment of 5G and RAN densification, Nokia has deployed an Energy Efficiency service that leverages AI to reduce energy usage in 5G networks by up to 30%. We would recommend that mobile operators put Nokia on their short list for any AIOps projects in the future.

Nokia's partnership with China Mobile on GenAI has led to significant advancements in autonomous network operations across the Guangdong, Beijing, and Fujian provinces, where China Mobile serves 190 million subscribers. This collaboration addresses critical challenges such as fragmented domain knowledge, limited data sharing, high analysis costs, and prolonged DevOps development.

Since late 2022, China Mobile and Nokia have been developing a GenAI solution for Operations and Maintenance (O&M), leveraging Nokia's AI expertise and deep understanding of China Mobile's autonomous network transformation. The solution uses the LangChain framework to integrate open-source Large Language Models (LLMs), localized knowledge centers, and diverse use cases, enhancing operational intelligence and paving the way for large-scale automation toward Level 5 Fully Autonomous Networks.

Quantifiable benefits include:

- 80% reduction in knowledge acquisition time
- 67% increase in knowledge coverage
- 72% faster data analysis by front-line engineers, saving 13,545 workdays annually
- Improved feature development, saving 7,680 man-days annually
- Faster development of operational reports, averaging 1 day per report compared to 3 days without GenAI, saving 11,520 workdays

Overall, the solution saves several million annually in the first phase of network operations. Phases 2 and 3 will enhance capabilities for recognizing intentions and generating solutions in complex scenarios. By utilizing AI Agent technology, we enable automatic collaboration between LLMs and

existing domain AI/ML models, driving China Mobile towards Level 5 Fully Autonomous Networks with expanding use cases for increased efficiency and innovation.

Huawei

Huawei embeds its AI capabilities in its Autonomous Driving Networks solution. The analysis module creates an extensive assessment and health analysis system that examines five dimensions: device, network, protocol, overlay, and service. It constructs an all-inclusive network monitoring and evaluation system, and distributes evaluation reports at regular intervals. The analysis platform differs from conventional systems that utilize fixed thresholds in that it employs a machine learning algorithm to detect network behavior changes. By leveraging historical network data, the analysis platform applies the Gauss process regression technique.

The algorithm automatically learns dynamic baselines of KPIs from several dimensions including devices, cards, ports, and optical modules. These baselines are updated daily, facilitating intelligent detection of network anomalies. Furthermore, the analysis platform employs multi-event association analysis based on dynamic correlations between KPIs. This method enables timely detection of behavior changes in the network's sub-health phase, and predicts and prevents faults before they occur.

The analysis platform conducts a network-wide full-flow analysis and visualizes application behavior exceptions. It captures and analyzes TCP packets transmitted across the network, displaying application interaction relationships and quality. To cluster application flows on the network, the Density-Based Spatial Clustering of Applications algorithm is utilized. This analysis method restores the hop-by-hop forwarding paths of packets, forwarding traffic, and link delay. It also enables the construction of multi-layer association and analysis capabilities that cover service flows, forwarding paths, and network services. This structured approach presents application behaviors and network quality to users.

IBM

IBM has been a leader in the AIOps market for years. In telecom, IBM Cloud Pak for Watson AIOps leverages the power of AI and ML at every stage of detecting, diagnosing, and resolving issues. It can engage with a variety of Ops data, including structured and unstructured data. IBM's Automation and Intelligent management solutions use Watson technologies to provide unique features such as AI/ML environment pattern recognition, dynamic topology, and AI-infused automation with Watson natural language processing. Additionally, it provides support for hybrid, multicloud, and cloud environments.

The product provides valuable insights in six different areas. Firstly, the event categorization feature automatically groups events to identify other existing events that share the same root cause. This helps to focus efforts on resolving the issue faster. Secondly, the anomaly detection feature detects anomalies earlier than rule-based alerts, and the story service generates a ticket, chat, or alert in the chat service of choice. Thirdly, the natural language processing feature automatically processes input data from unstructured sources, such as logs, tickets, and chat, to extract the most informative

texts to enrich predictive alerts. Fourthly, the incident localization feature derives the root fault component and blast radius of affected components to isolate and resolve problems in real time. Fifthly, the prescriptive action feature advises teams based on inputs across DevOps, potentially helping them fix an outage faster by arming them with learnings from prior outages or incidents. Finally, the change-risk remediation feature uses IBM's deep learning models to discover the relationships between changes and provide risk predictions.

The event manager component of IBM Cloud Pak for Watson AIOps includes Netcool Operations Insight, including Netcool/OMNIBUS and the Agile Service Manager topology function. This component helps manage and analyze events across hybrid, multicloud, and cloud environments.

The IBM watsonx platform leverages foundation models and features three core components:

- watsonx.ai
- watsonx.data
- watsonx.governance

It also includes a set of AI assistants designed to help scale and accelerate the impact of AI using trusted data across the business. The platform facilitates the training, tuning, and deployment of AI models, scales data where it resides, and designs trustworthy AI workflows.

Segment Outlook

To say that this is a nascent market would be an understatement, as the industry is facing significant challenges in terms of aligning organizations to fully realize the benefits of AIOps. Acquiring high-quality data that can predict faults and capacity overload continues to be a major obstacle. Data is either scarce, limited by privacy concerns, or not shared internally, which hampers progress. Despite investing in data lake projects, the industry has made only marginal advances in the past decade, as evidenced by dubious metrics on NPS, churn, and OPEX to revenue ratio.

The transformative potential of **Generative AI** on the telecommunication industry is a key enabler on the path to full autonomy. And looking ahead, we need to be ready for the possibility that the traditional Network Operations Center (NOC) might just become a thing of the past.

Generative AI enhances productivity by automating mundane tasks and suggesting useful hints to perform tasks more efficiently. The technology personalizes experiences and products to individual preferences, improving engagement and satisfaction. It aids decision-making with sophisticated simulations and innovative problem-solving approaches. For example, we interviewed some leading telecommunication companies operating call centers that deployed GenAI assistant technology. The early results showed that entry-level employees showed 24% and more senior-level employees saw 10% productivity gains six months after deployment.

Using Generative AI, while transformative can also introduce challenges, including incorrect output, especially when input data is ambiguous. Ensuring the reliability and accuracy of AI-generated content can be difficult, necessitating human oversight and intervention.

When dealing with complex topics that require deep expertise or nuanced understanding, Generative AI might struggle to produce accurate or meaningful content. For instance, generating a detailed response as to why a customer's bill is higher this month than the previous month. Or quickly assessing the impact of a network outage because the cause requires interpreting multiple data streams from different domains to infer correlations.

Generative AI models rely heavily on the quality and specificity of the input they receive. Vague, incomplete, or ambiguous inputs can lead to outputs that are off-target, irrelevant, or nonsensical. LLMs may misinterpret the context or intention behind a given input, leading to responses that, while grammatically correct, may be contextually inappropriate or miss the mark in terms of user expectations.

Addressing these pain points requires a balanced approach, combining technological advancements with ethical considerations, human oversight, and clear regulatory frameworks to ensure Generative AI is used responsibly and effectively.

Cross-Domain Service Orchestration

Definition

Software in this segment handles end-to-end orchestration of services, almost always crossing multiple domains and interacting with individual domain orchestrators. Readers may find this dedicated research note worth reading. Cross domain service orchestration ("CDSO") performs two distinct but related actions:

- linking together network segments across domains.
- creating network or customer facing services, complete with user/service configuration, and in doing so may handle non-network commercial actions as well (for example, configure charging and billing components).

CDSO is distinct from, and coordinates across, one or more technology specific domains (or administrative/ownership domains in some cases). The detail of each sub-domain is handled by its respective domain manager or orchestrator. In the modern, self-managing network the orchestration process enacts three previously independent operational stacks:

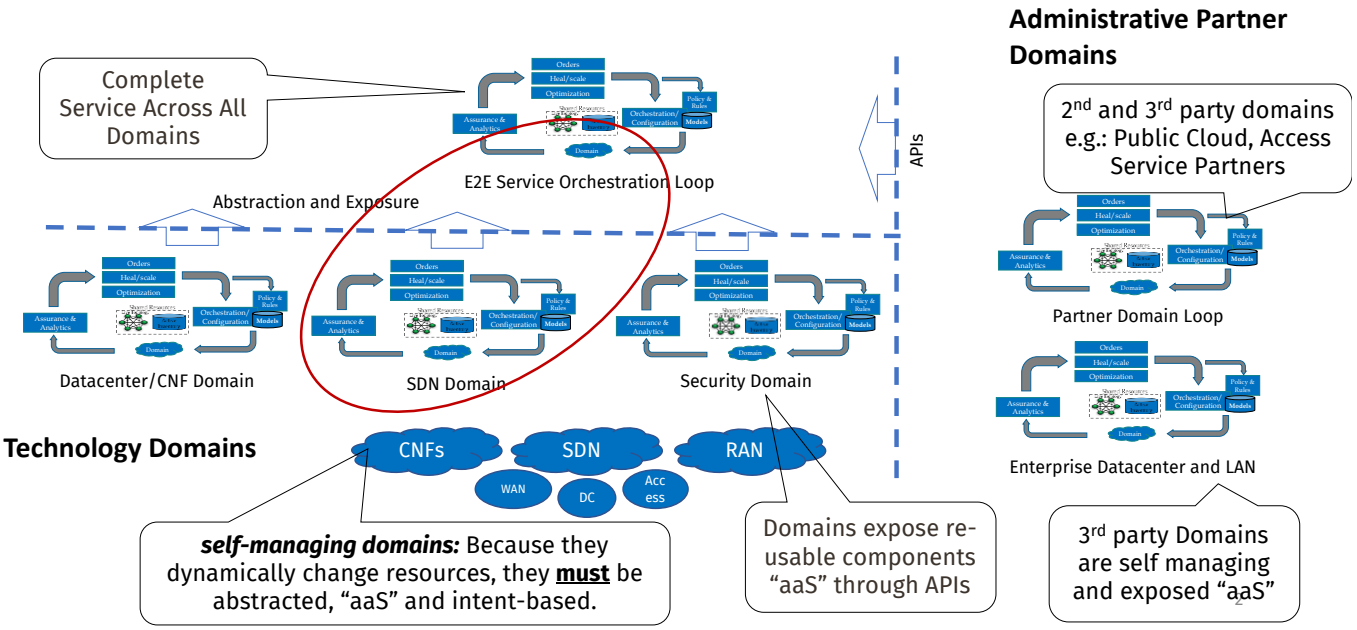
1. Fulfillment/provisioning
2. Assurance (self-healing)
3. Capacity Management (Self-scaling)

The intelligence necessary to inform at the service or cross-domain orchestration layer the actual collection and processing of fault, performance and other assurance input data is typically handled external to the orchestrator and is classified in the **AIOps** category.

In almost all cases CDSO maintains a dynamic, real-time directory of services and aspects of their state – things previously held in semi-static inventory. It is important to recognize that the components of a service are in abstracted form, and the implementation details of each domain are retained in their respective domain directories. As a corollary, the interface between CDSO and one or more domains is an abstracter "aaS" interface – which allows each domain to dynamically self-manage implementations (heal, scale, move as needed). CDSO takes as its input information from the order management process which in many cases will come via self-service over an API – or in the case of network services, from another system.

Below we illustrate the relationship between CDSO/service orchestration, technology domains (domain orchestrators) and partner domains (which may be CDSOs operated by other CSPs or public cloud firms for example).

Figure 15: Domain and Cross-Domain Service Orchestration



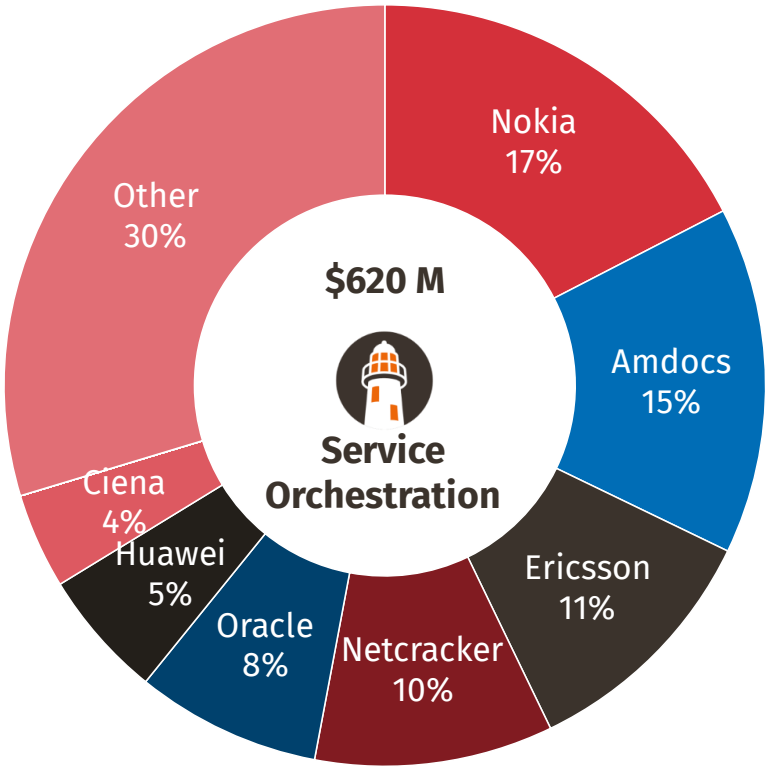
Source: Appledore Research

The CDSO segment includes end-to-end orchestration control of network services and customer services.

Market Size and Vendor Share

Appledore estimates that the market for E2E (or Cross-Domain) Network and Service Orchestration software was **$620 million** in 2023. That is down 2.5% from the $640M we assessed for 2022.

Figure 16: Cross-Domain Service Orchestration Market, 2023



Source: Appledore Research

In CDSO, we credit **Nokia** with the largest market share (17%), followed closely by **Amdocs** (15%), **Ericsson** (11%), **Netcracker** (10%). Just outside these leaders are **Oracle** (8%), **Huawei** (5%), and **Ciena** (4%).

The CDSO segment is contended by a large number of firms, with diverse strategies. For simplicity, we can classify them into:

- NEPs that must deliver complete automation (**Nokia, Ericsson, Huawei**,...),
- ISVs from the older "OSS" space that focus on services (**Amdocs, Netcracker, Oracle**)
- Disruptors of many forms, bringing new technologies and solution packages to the market (**IBM, Rakuten**, ...).

Others (such as **HPE** and **Ciena Blue Planet)** combine characteristics and aspects of all three.

Nearly all the products in this segment are new, and replace legacy provisioning systems based on older, deterministic systems. The older systems were typically not intent-based, made minimal use of self-managing domains. Investments in these products range from ~5 years for the earliest

movers, to a large number of new and deeply revised products that were launched in the last 30 months. We covered this transformation in depth in this market outlook covering the state of the CDSO market.

Examples of specific products include **Nokia** Digital Operations Center, **Ericsson** Orchestrator, **Huawei's** Intelligent Service Engine, **Ciena Blue Planet** Multi-Domain Service Orchestrator (MDSO), **Amdocs** Intelligent Networking Suite, **HPE's** Service Director, **Inmanta's** orchestrator, **IBM**'s CloudPak for Network Automation, **Oracle's** Unified Orchestration & Assurance, **VMware's** Telco Cloud Automation, **Rakuten Symphony** and **Netcracker's** Cross-Domain Service Orchestration.

An alternative to the commercial orchestration market (and to other segments in our taxonomy) is the Linux Foundation's **Open Network Automation Platform** (ONAP) Project, but Appledore see this becoming more of a source for base code than a finished product (as most opensource libraries have always been!).

Profiles exist for most of these CDSO vendors, and may be found here.

Segment Outlook

CDSO decreased very slightly both with the overall NAS market, and as a proportion of the overall NAS market (10.2% in 2022 versus 10% in 2023). In 2022, CDSO grew significantly both in absolute and relative terms, driven in part because the foundational domain automation software was beginning to fall in place. We believe CDSO will return to growth as new services and disaggregated, higher-band 5G, mature.

CDSO is being driven by market demands for both agility and low-cost rearrangement. In manufacturing this sort of low fixed-cost flexibility is referred to as "mass customization"—and as customers and vertical industries demand increasingly customized solutions this must become a focus of our industry. As we reported in our Market Outlook the diversity of suppliers provides choices for CSPs that have different needs and resources. **NEPs** provide a simple, pre-integrated, and low risk solution for smaller CSPs. **ISVs** likewise excel at managing a complete project, and de-risking it, but coming at it from the top-down, via the service, and maintaining multi-vendor and multi-technology independence as a strength. The **disruptive technology innovators** are a higher complexity, higher risk path but promise greater overall levels of automation and lower ultimate TCO. There may be no right answer where "one size fits all".

One leading driver of CDSO is the shift to modern, dynamic, **enterprise WANs** that include security (SASE), SDWAN, public cloud integration, and integration with digital supply chain partners. Many of the leading CDSO vendors announced deployments to support "SDWAN+" as early as 2018-2019 and have subsequently grown and matured their solutions. We covered this maturation and the early gaps in our enterprise/SDWAN research track.

Another driver is the long-talked-about **network slicing market**. We believe in the mid-term, network slicing will focus on a manageable number of standard network slices to which customer services are mapped—for example a low latency premium priced slice for myriad latency sensitive

and valuable traffic, as opposed to a general-purpose slice. This, in fact, began to take off in late 2022 and early 2023, with support (and demand) from handsets and some applications. We also expect slices for various IoT technologies but anticipate that most of these will be mapped to pre-defined slices (a few large enterprises may demand custom slices, the market will tell over time). Demand for much larger volumes of customized slices remains uncertain and further in the future. This reality may contribute to the 5G deployment slowdown that currently affects the industry.

A further set of use cases driving CDSO concentrate on **automating network reconfiguration** and ongoing operations for existing capacity—the goal being to automate manual tasks, shortened time to value and reduce the inevitable human errors.

Unlike the domain management market (which has a strong affinity to network equipment suppliers of that particular domain technology – those with the expertise), the CDSO market is largely both technology- and vendor-independent. This is not to say that the large NEPs do not participate, but that in many cases they must act as multi-vendor and technology-independent suppliers of CDSO software and processes. We consequently see both NEPs such as Huawei, Ericsson, and Nokia, but also IT and ISV firms such as Amdocs, Netcracker, HPE, Oracle and IBM – plus many specialty entrants to the market. This supplier diversity is both a boon for buyers but also a challenge for those seeking larger market share.

Continuous Testing

Definition

Continuous Testing is a market segment reflecting a new reality but building on long-established expertise in test and measurement. As always, the driver is dynamic, self-managing networks which both increase operational volume and complexity, but also create opportunities for on-demand deployment and remote, immediate healing and scaling.

Traditionally, testing capabilities have been used up-front to qualify and characterize equipment in the lab; then at turn-up in the field, and finally as a tool of human investigators when a problem is identified by service assurance, but not fully understood.

Continuous Testing refers to the application of similar testing and validation processes in a more automated and software centric world, eventually becoming part of a CI/CD world. It encompasses onboarding, lab testing, integration testing, deployment testing, trouble investigation/service validation, version management, and CI/CD tasks.

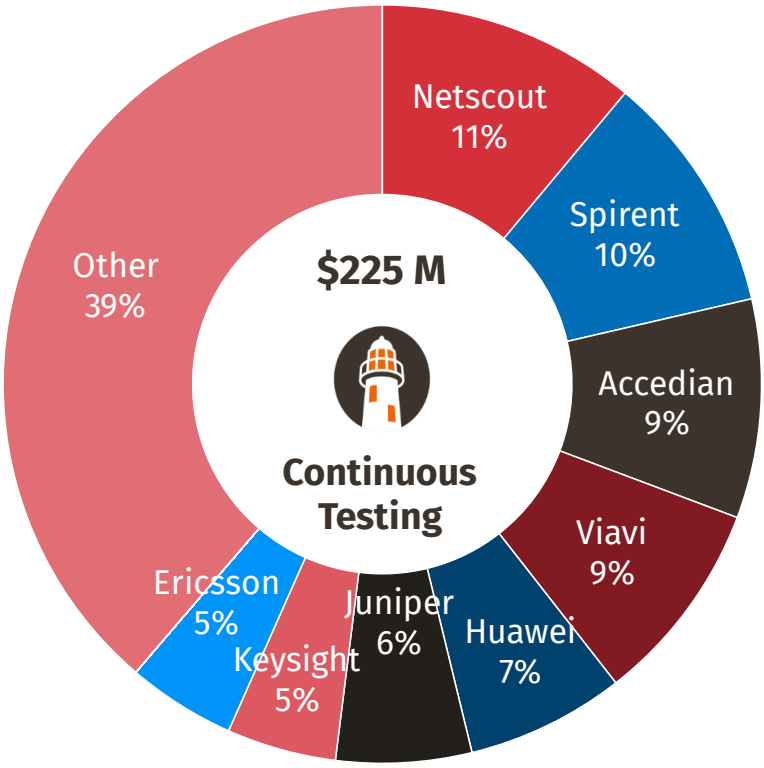
“CT” still applies to hardware NFs (but less and less); increasingly to software in CI/CD environments, and even more increasingly, to services in a service-oriented-architecture in which services are made up of smaller services – facilitating loose coupling and high degrees of re-use.

Market Size and Vendor Share

Appledore estimates that the market for Continuous Testing was **$225 million** in 2023 (up 1.6% from the $218 million we estimated in 2022).

Within the confines of telco Network Automation Software, the Continuous Testing segment is led by **NETSCOUT** (11%), **Spirent** (10%), **Accedian** (9%) and **Viavi** (9%).

Figure 17: Continuous Testing Market, 2023



Source: Appledore Research

Segment Outlook

Traditional test and measurement were never designed and productized for this environment – it was, and often still is, the bastion of deep lab and pre-deployment expertise – not performed often, but when performed, performed in great detail.

Today's environment both demands automation to deal with volume, but invites these complex, highly technical methods as tools to evaluate and diagnose the network and services throughout the lifecycle, specifically including run-time.

Not long ago we saw "Test" transform to in-network monitoring systems (first SS7 link monitoring and later IP monitoring). Now we are seeing the packaging of T&M methods for automation, and their [eventual] use before the instantiation of every CNF/VNF/workload and service. Add to this, new methods such as Digital Twins, and Test & Measurement has the opportunity to move from lab to run-time operations, with a 10-100x increase in test volume. This is highly lucrative growth, but we caution that it can only achieve this growth when packaged and priced for volume. In such field deployment, test controllers will in effect become test domain controllers, operating in close association with life-cycle orchestration to perform tests at the proper points in a life cycle.

We believe that testing methods will be increasingly needed not only at "qualification" time, but each time a CI/CD component arrives; whenever a service instance is created; whenever a service

instance shows potential misbehavior and would benefit from deeper investigation (testing). This implies that testing will go from high cost-per-test niche use to low cost-per test mass use, applied automatically, throughout the software or service' life cycle – and hence the name.

Ideally, the tests, methods, and metrics (e.g.: desired performance, thresholds for failure) would be developed up front as part of a true "Dev-Ops" process, captured in the CNF/VNF models, and loaded into appropriate systems (scripts to test controllers, trigger points to monitoring systems and/or orchestrators). Such a process will allow for much deeper assurance/test information to be gathered automatically, and also provides for consistent "best practice" methods and data to be widely disseminated to myriad operators and systems rather than re-invented.

Appledore believes that CT must and will be automated with pre-defined test scripts along with means of automatically running consistent tests on lab samples, digital twins, and production samples. We further believe that this will migrate from lab and offline to online/in-network test and validation using the exact same logic, under orchestration control – e.g.: run when an issue arises to either validate or understand performance.

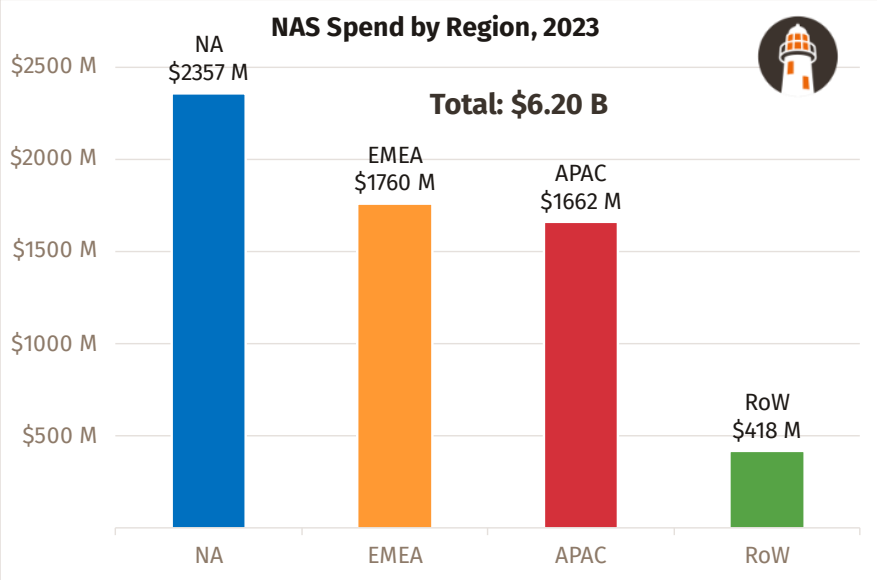
A near term headwind for this segment is the reluctance of CSPs to go fully cloud-native. Our recent checks at industry trade events and with clients, reveal a recurring frustration regarding cloud-native technology deployments. It seems that many CSPs still face challenges in achieving a fully cloud-native 5G architecture, and more importantly, they struggle with how to monetize and address business issues from the end user's perspective. As a result, the need to deploy active virtual testing and other continuous test functions is limited.

Regional Market Share

In the course of our NAS analysis, it is becoming less reasonable to consider a truly global market. Regions of the world of course have their own distinct needs, but for all sorts of reasons even global vendors do not compete on even terms in major geographies. It is therefore more helpful to consider market leadership on a regionalized basis.

As with our other analysis, a degree of interpretation and informed estimation is required. Few vendors share a common breakdown of regions, and even fewer provide a common breakdown of NAS revenue.

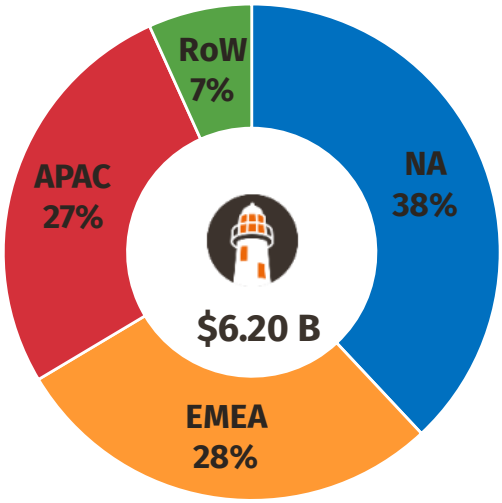
Figure 18: NAS Spend by Value by Region, 2023



Source: Appledore Research

By our estimates, North America is the largest region, EMEA and APAC are broadly comparable in value.

Figure 19: NAS Spend by Region, proportional, 2023

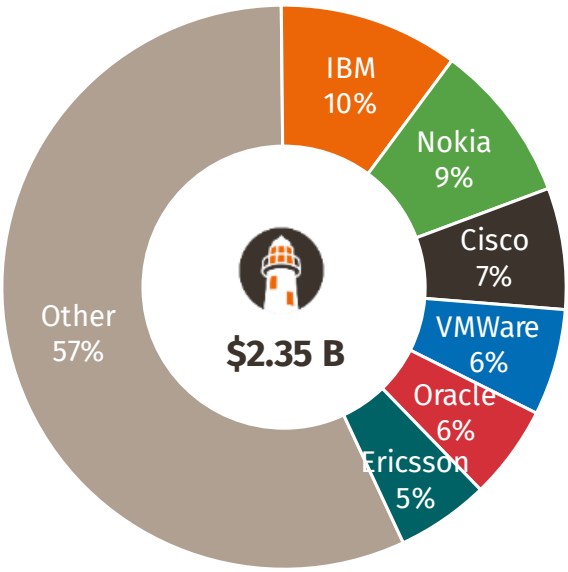


Source: Appledore Research

North America

In North America, we credit **IBM** with the #1 spot (10%), with **Nokia** a close second (9%).

Figure 20: NAS Market Share, North America, 2023

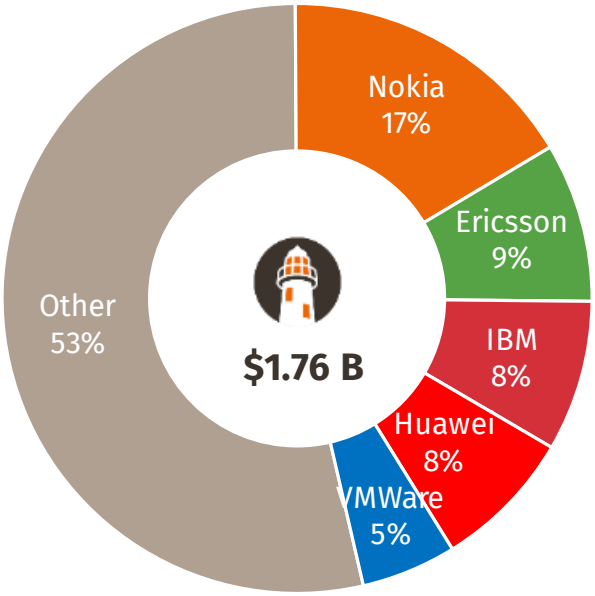


Source: Appledore Research

EMEA

In EMEA, **Nokia** leads the NAS market with 17%, **Ericsson** is second with 9% of the market.

Figure 21: NAS Market Share, EMEA, 2023

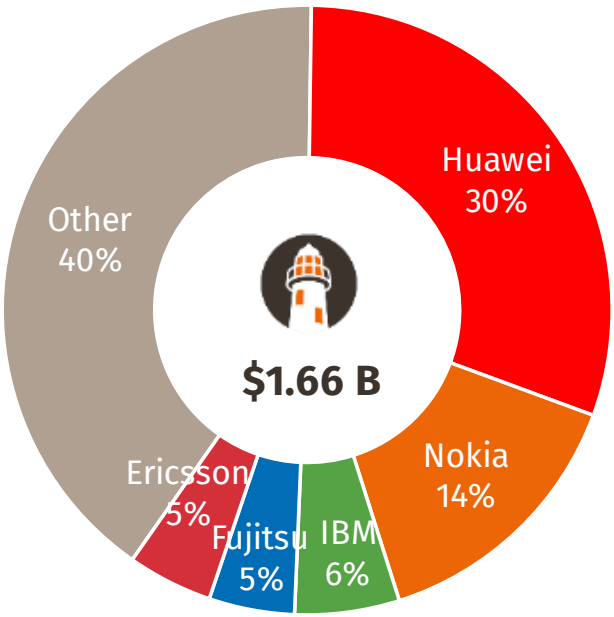


Source: Appledore Research

APAC

In APAC, Huawei is the clear market leader in NAS (30%), followed by **Nokia** (14%).

Figure 22: NAS Market Share, APAC, 2023

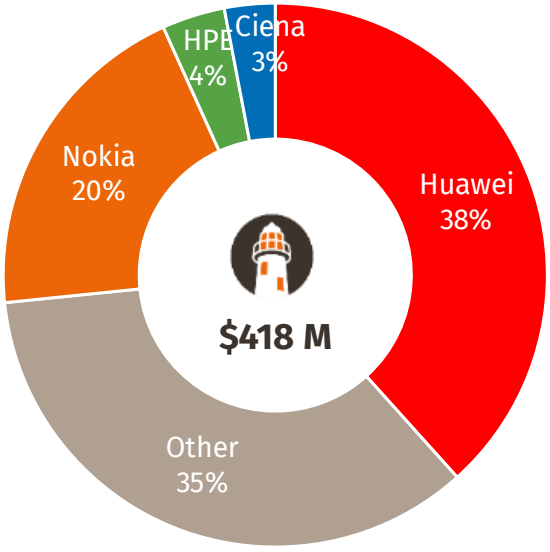


Source: Appledore Research

Rest of World

The world market beyond NA, EMEA and APAC still represents around 7% of the total global market. **Huawei** leads this market in this region (38%).

Figure 23: NAS Market Share, Rest of World, 2023



Source: Appledore Research

CONCLUSION

Key takeaways from this analysis are:

- Despite positive indicators in 2022, the pace of investment in next-gen operational support systems significantly slowed in 2023.
- The investment agenda at telcos has tightened, focusing on high-impact, low-investment areas such as reducing energy draw and quick wins from customer experience improvements.
- NAS, like all network software, remains tied to the network hardware investment cycle. Software spend is often budgeted for as a percentage of capital spend on network hardware, and when that decreases as rollouts conclude, telcos expect a macro-level reduction in software investment, particularly in 5G and fixed networks.
- Major acquisitions, which take time to finalize, may have created some uncertainty for CSPs in their investment plans, leading to temporary delays spanning multiple quarters.
- CSPs are struggling with taking successful network automation proofs-of-concept into production, as large-scale automation benefits often require challenging organizational changes.
- Ironically, the rise of GenAI has renewed interest in older AI/ML applications. While many GenAI possibilities remain speculative, practical applications of AI/ML in networking, a trend for at least five years, are now mainstream and worthy of increased investment.

Nonetheless, we remain optimistic about the outlook for NAS. The technologies are already mature or rapidly maturing, aligning with telcos' strategic goals of lowering costs, increasing agility, and making smarter use of energy and personnel. Numerous examples showcase the potential achievements. The pressure on telcos to present credible plans for improved performance persists. While NAS spending may have flattened for now, it remains the only realistic solution for telcos to meet their strategic objectives.

Annex A - Notes on Scope and Definitions

Definitions

Term	Definition
CSP Revenue	Total revenue from CSPs including Hardware, Software and Services
Software and Services	Total revenue from CSPs for Management / Virtualization Software and Services (does not include, for example, VNFs)
Software Product	Proportion of S&S that is in the form of licenses or SaaS
Software Related Services	Proportion of S&S that is software specific customization and integration to legacy software

Basis for Inclusion in Market Share

Each of our new taxonomy segments has a legacy/existing analog. Forward-looking domain managers for example, have as analogs EMS systems of the past. In our analysis, we omit older technology if it is not explicitly flexible, rule/orchestration driven, and designed to facilitate a cloud-native and automated future. The mere fact that it mechanizes the collection and forwarding of alarms and other data is not sufficient for inclusion – as this would not effect an efficient, agile and cloud-native future operational state.

Similar analogs exist for network data management (fixed inventory), service orchestration (workflow-based mechanization), and AIOps (traditional fault and performance → NOC management). There is effectively no analog to CT or cloud infrastructure, except PNFs themselves (boxes).

Our objective is to focus on those functions that are being deployed to fundamentally change how we operate networks, with an emphasis on automation, and within that, automation achieved through elegant engineering rather than brute force coding.

Cloudified Network Functions

Network functions, such as RAN, Routers, Transport, Optics, are outside the scope of this report. They are the devices whose lifecycles are automated. This applies regardless of whether they are delivered as traditional hardware appliances (PNFs), or software (VNFs and CNFs), whether on VMs, bare metal or in containers. Like VMs and containers themselves (discussed in distributed cloud infrastructure), these are necessary to automation but do not implement automation themselves. Cloudified routers are routers. Cloudified V-RAN is RAN and reside in the network category. They are in fact the items being automated by NAS.

However, because of its current inclusion in service assurance, we have made an exception for virtual probe, test and measurement functions. For simplicity we have included this within the network data management category.

We generally exclude network functions (VNFs and CNFs) from our analysis. However, we include these in our analysis in two cases:

- Where they contain modern automation logic and cannot be easily separated from domain managers and controllers. Examples are SDWAN CNF edges, and cloud/ aaS based cloud security gateways, as well as other that exhibit similar distributed intelligence with that intelligence embedded in the CNFs themselves. These are included in domain management.
- Standalone (v-probes) or embedded test/telemetry functions within CNFs, are shown in light green below as “measurement functions” and “inline test functions”. These are included in our market share analysis as part of network data management, because of their existing close coupling with service assurance systems.

About the Authors

Patrick Kelly has more than 25 years of experience in product management, business development, and technology consulting. He has advised executives and developed actionable business plans to help hundreds of technology companies profit in high growth software segments of the market. He is the leading authority and has published research in the areas of cloud economics, virtualization of the network, NFV, SDN, machine learning, orchestration, analytics, service management, and customer experience management.

Patrick founded Appledore Research in 2014 to focus on the business impact of cloud and virtualization in the telecommunication market. Prior to Appledore, he was Research Director at Analysys Mason, co-founder of OSS Observer (acquired by Analysys Mason in 2008), Director of Product Management for Aprisma (acquired by CA), and held many technical roles in the field supporting both enterprise and service provider customers.

Grant Lenahan provides a unique combination of management and technical acumen, combined with 30 years of successful innovation in both technology and business models. He most recently served in the office of CTO for Ericsson. Through his career, Grant has specialized in transforming telecom software and service businesses in the face of dramatic market and technology shifts, positioning the businesses for survival and growth in new environments.

Grant has deep experience in understanding market and technology shifts, and the consequent opportunities and threats that these shifts create. He has consistently guided the Telcordia and Ericsson software product portfolios to thrive on these changes. Grant holds a Bachelor of sciences from Drew University and an MBA (SM-Management, SM-Engineering) from Massachusetts Institute of Technology.

Francis Haysom has 25 years of experience in telecoms BSS and OSS software. Previously he was responsible for innovation and strategy in Ericsson's software solutions business and in Telcordia. Within this role he set and reviewed the strategic direction of both product and customer program delivery.

Before Telcordia he was VP - OSS Architecture at Cramer Systems. He was one of the original employees of Cramer and was responsible for the development of its professional services organization and its strategic deployment architecture. He has also led BSS development teams at BT and Convergys.

Francis received his PhD from the University of Bath and a BSc in Engineering Science from the University of Exeter.

Robert Curran has 25 years of experience in the telecom software industry. Prior to Appledore, he was CEO at Aria Networks, a pioneer in the use of AI to design and optimize telecom networks.

Previous roles include Strategic, Corporate and Product Marketing at startups and blue-chip companies such as Ericsson, Amdocs, Cramer and Orange. Robert started his career as software engineer.

Robert has a B.Eng degree in Electrical and Electronic Engineering from Queen's University, Belfast.

Insight and analysis for telecom transformation.

@AppledoreVision

Appledore Research

www.appledoreresearch.com

info@appledorerg.com

+1 603 969 2125

44 Summer Street Dover, NH. 03820, USA

Appledore RESEARCH