Perspective

A move to cloud changes the game for Deutsche Telekom's next-generation IMS

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1. Executive summary

1.1 Deutsche Telekom's NIMS success is built on solid foundations

Deutsche Telekom's (DT's) next-generation IMS (NIMS) project in Germany is a radical implementation of an IMS for fixed-line voice services based on DevOps automation principles and a cloud-native telco cloud. Few operators have achieved such a far-reaching deployment of a critical network function in the cloud at scale and with industry-leading levels of operational automation. The NIMS project has overcome challenges associated with the telco cloud in the areas of technology immaturity, robustness, performance and availability thanks to the exceptional collaboration that DT has fostered with its technology partners and the pioneering developments that they have achieved in the area of telco cloud automation. These achievements have resulted from the ambitious vision that DT set out for its NIMS project, which builds on earlier transformational targets for the fixed voice network.

DT's journey towards running IMS components in the cloud began in 2015, when efforts to address issues in its fixed VoIP network resulted in critical organizational changes. These changes included the de-siloing of team structures and the introduction of new processes and skills to enable greater operational automation. This made it possible to manage the IMS more efficiently than is usually possible with a physical network function (PNF), but certain challenges remained. As components of the legacy IMS were nearing end-of-life, DT decided to further transform its VoIP network with a cloud-based transformation initiative, driven by what it believes is a 'game-changing' vision of zero-touch, or 'brutal' automation. DT's experiences provided strong foundations for NIMS, to which the team added support for platform-based, cloud-native automation, a DevOps approach and vendor collaboration and co-creation to realize its vision.

1.2 Vendor selection and an 'automate-first' mindset were critical success factors

NIMS is underpinned by a state-of-the-art, horizontal cloud platform that is completely decoupled from the network functions (NFs) that it hosts, which gives DT flexibility over its choice of NF providers. The operator is future-proofing its telco cloud by ensuring that it is based on open-source technologies and that it supports both virtual machine and container-based approaches to network function virtualisation. However, DT needed to select vendors that would support its aims and understand the challenges presented by the disaggregation and separate procurement of telco cloud components.

DT selected a mix of vendors, some with which it had existing relationships and others that were new to the company, based not only on their technical capabilities and product excellence, but also on their willingness to collaborate to achieve DT's NIMS vision. The majority of the NIMS telco cloud has been created with contributions from six vendors. All had to demonstrate their commitment to the 'automate first' targets of the project, including the supporting centerpiece, DT's Automation Operations Platform (AOP). AOP distils and extends DT's pre-NIMS automation experience and provides a wide range of functionality, including Network Function Virtualisation Infrastructure (NFVI) automation, an extensive set of CI/CD pipelines, support for monitoring, telemetry and analysis, orchestration capabilities, inventory and a unified user interface that provides a 360-degree view for all NIMS operations.

1.3 DT's NIMS achievement yields valuable lessons for the industry

The NIMS telco cloud platform is now live and once roll-out has been finalized, it will support up to18 million subscribers and around 100 interconnect partners with high levels of service quality. This paper tells the story of DT's NIMS transformation journey to the point of its Interconnect Service launch, its plans for future development, the business benefits that the company expects to achieve and the lessons that apply to the cloud-native operation of any large and complex network function. The DT NIMS project is a blueprint for further network transformation within DT, paving the way for a more efficient and automated network overall. It can also help the wider telecoms industry to understand the art of the possible in automating telco cloud, provided that the right critical success factors are in place.

2. Laying the right foundations for the NIMS project

2.1 Background to the NIMS project

DT's next-generation IMS (NIMS) project is a radical implementation of an IMS for fixed-line voice services based on DevOps automation principles and a cloud-native telco cloud. Many operators have attempted cloud-based network function deployments, but DT's NIMS project differs from other deployments significantly because of the extraordinarily high levels of automation being implemented, the extent of the NIMS ecosystem and its unconventional choice of supplier partners, and the exceptional level of collaboration driving its progress. DT is assessing whether NIMS will be the basis for shaping digital transformation in the wider company.

DT's journey towards NIMS began in 2015 when the operator took steps to address quality issues in its fixed VoIP network. DT was determined to create a world-leading voice service and appointed an experienced leader, Christoph Hilz, to tackle the challenges that it was facing with its supplier's 'black box' IMS and its environment, which were proving difficult to troubleshoot because they lacked appropriate instrumentation. Hilz, whose title today is Tribe Head Voice and Messaging (DevOps), and his team spent months working round the clock to improve DT's voice network and, as a result of this experience, Hilz, became convinced of the need for the following four capabilities.

- Elimination of engineering, validation, planning and operation silos.
- Acquisition of internal knowledge and expertise rather than a dependency on vendors' expertise.
- 'Brutal'[1] operational automation instead of manual processes.
- Support for live and continuous network upgrades in place of night shifts working in maintenance windows.

2.2 The importance of organizational change

DT commissioned a review of the root causes of its voice network issues and realized that its own suboptimal ways of working and siloed Engineering, Planning and Operations organisations had contributed to its challenges. When the operator began a series of Excellence programmes in 2015 to support the implementation of a world-class voice service, it was inevitable that one of these programmes would focus on internal reorganisation.

In 2016, DT created a new department that brought together the functions of voice network engineering, planning and validation in a single organization that initially had informal links to operations. This organization proved foundational in breaking down functional silos and in encouraging direct collaboration between members, 2 years before a DevOps approach was formally introduced. The new voice network organization enabled DT to address the difficulties of changing organizational culture and processes in advance of the major technology change that NIMS represents. The voice network organization is now the blueprint for organizational change across DT Germany's technical division. This initiative is driven at C-level within DT, a critical factor for success.

[1] The term 'brutal automation' was coined by DT's deputy CTO, Arash Asouriha. DT has played a leading role in facilitating network automation initiatives such as ETSI Zero Touch Service Management (ZSM).

2.3 Ambitious targets for legacy network roll-out and automation paved the way for NIMS

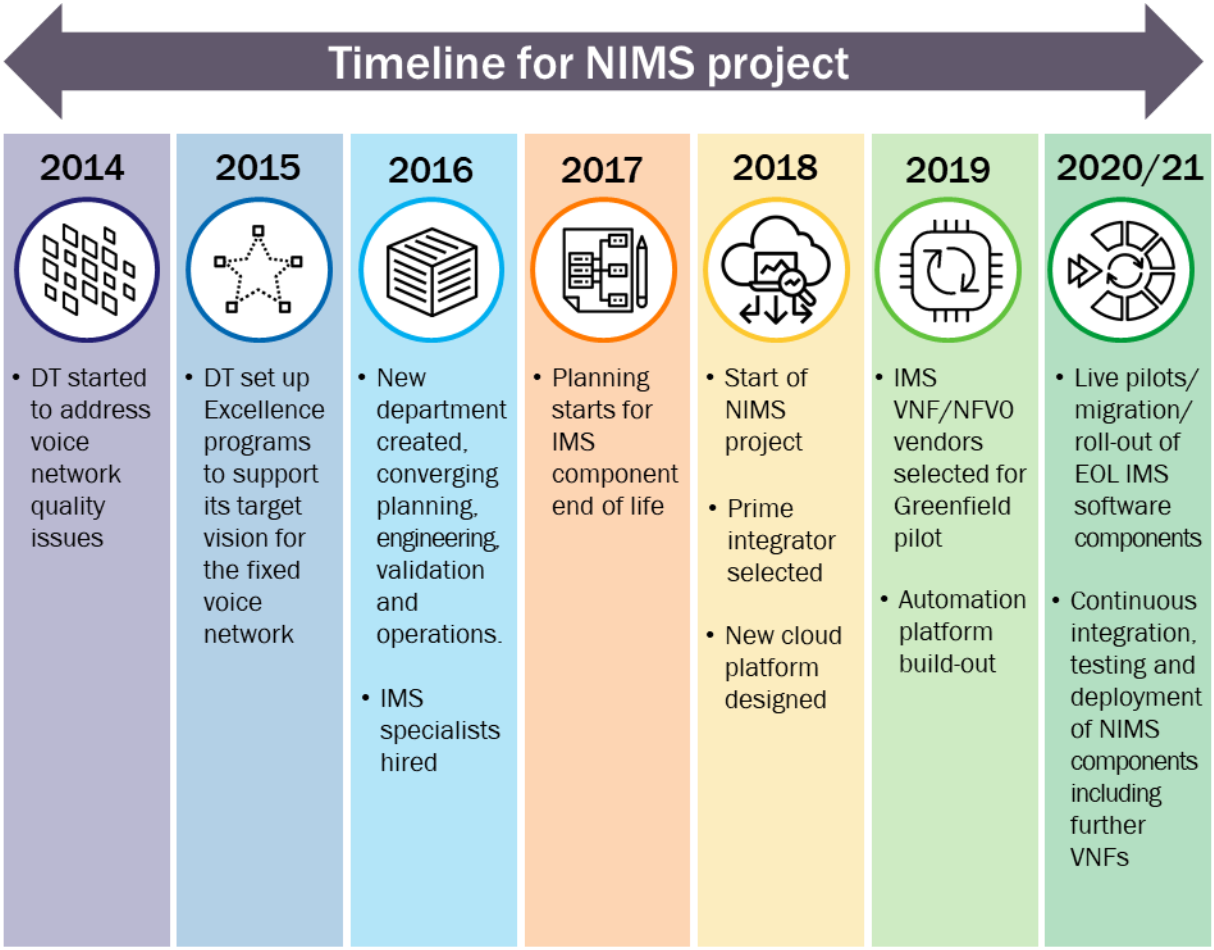
DT has undertaken its journey towards a cloud-native voice service in stages. In 2017, the operator started planning for the end of life, in 2020/2021, of certain components within its fixed voice IMS: namely the access and interconnect session border controllers (SBCs) and the IMS core. These functions are at the heart of the NIMS project.

However, prior to their replacement, DT had wanted to achieve ambitious service excellence and quality goals based on its legacy IMS. By 2016, in addition to the organizational changes described in the previous section, the operator had made changes to its processes and skills, hiring additional IMS skills from around the world, increasing the diversity of its team, its openness to change, and its ability to write its own code/scripts. DT also set ambitious new targets for its legacy IMS system. It wanted to increase the number of platform upgrades a year from fewer than one, by introducing an agile software lifecycle to the IMS platform. To achieve this goal, DT needed to accelerate every phase of the software delivery lifecycle for new release packages, which can consist of up to eight individual IMS components (including the P-CSCF, ABGF, I-CSCF, S-CSCF and iDNS). For example, DT aimed to reduce the time taken to prepare the lab for testing of a new release package from 40 days to 5, the time allocated to regression testing from 280 days to 20, and the time for piloting a new release from 140 days to 10. The vision was to reduce the time spent on platform roll-out from 220 days to 2 days for each system component involved in the roll-out, regardless of the number of individual components deployed.

This was an audacious vision for a traditional network function, and it was greeted with scepticism at first. The vision nevertheless challenged the voice team to innovate a response using 'brutal automation'. As part of a turnaround program, the team used its coding/scripting skills and developed a fully customized software upgrade centre with the system vendor. Its goal was to replace the practice of upgrading one location at a time, box by box, with an approach that enabled entire locations to be deployed from a single set of scripts. The team gained confidence from achieving the stringent objectives with which it had been challenged and had its first taste of the game-changing power of automation to improve quality and efficiency.

Although this level of ambition was outstanding from the perspective of a legacy network function, potential for further improvement remained. Time to market for new features was still too slow for a future cloud-native world in which DT envisages it will receive new releases or release updates from VNF vendors every 2 weeks. DT had laid solid foundations for change but had reached the limits of what was achievable with a traditional PNF. The operator remained dependent on vendor software delivery processes, even though the software itself was developed using agile methods. The automation solutions developed for one vendor's PNF were customized, so they could not be reused by PNFs from other suppliers. In addition, the utilization of its servers/appliances continued to be low because they were dimensioned for busy hours/signalling storms, and capacity was dedicated to specific IMS components without the option of automated scale-out and/or hardware resource sharing across a telco cloud platform.

Figure 2.1: NIMS project timeline



Source: Analysys Mason

2.4 NIMS vision and targets

In 2018, DT started its NIMS project, a cloud-native implementation of a fixed voice IMS running on a common telco cloud across multiple active locations. This environment went into production with its first service deployed in September 2020, thus achieving its requirement to go live before DT's legacy IMS components reached their end of life in 2020/2021. The new fixed voice platform now supports the migration of up to 18 million subscribers and around 100 interconnect partners. The project has a service excellence and quality focus and meets stringent KPIs in areas such as call set-up times, MOS and network recovery times. DT and its NIMS partners are in the process of refining operational automation within the platform so that NIMS meets the operator's most-ambitious targets yet to increase the velocity of software deployments in the network.

The NIMS vision, based on cloud principles, is simple and radical. It should only take **3 months** to bring features from specification to roll-out, compared to the 1–2 years, on average, that it takes in the traditional IMS environment. It should take **2 days** from the time a new release comes in from a vendor to roll it out to all live sites. This means that 2 days are required to carry out processes such as onboarding the new release into the lab, validating and canary testing it and deploying it across all live sites. It should take **1 day** to implement any patch, and there will be **zero** nightshifts (for dedicated 'maintenance windows') because all processes can be carried out in working hours. DT refers to this set of goals as its '3-2-1-0' vision.

DT believes these targets are not only achievable, but game-changing, providing a compelling foundation for future cloud-based transformations of the network. However, to realize them, DT recognized that it would need to bring in further change in three key areas.

- A new, highly automated architecture capable of supporting validation that needs to be done in seconds rather than days and testing and change management that are 100% automated through a 24x7 CI/CD pipeline.
- Further organizational and skillset change to move the organization from its original waterfall/sequential software delivery process to a full lean/agile CI/CD process.
- A new relationship with vendors in which they become deeply integrated partners that collaborate to bring DT's fixed IMS architecture and automation to life.

To achieve these goals, DT needs to break down existing processes and open up a new, strategic opportunity for the future. This will allow DT to reduce its dependence on vendors and to play a larger role in increasing the quality and efficiency of a large network function deployment. DT understands that succeeding with NIMS, including its telco cloud and automation foundations, will yield lessons that it can apply to the cloud-native operation of any large and complex network function in future. This project is paving the way for a more efficient and automated network overall.

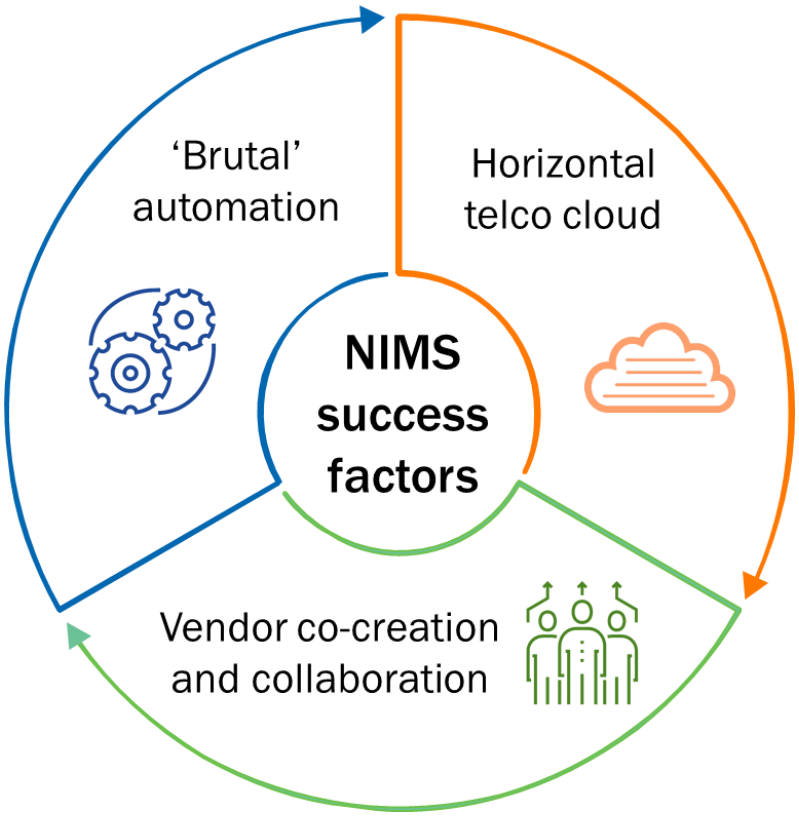
3. Key NIMS components are critical to project success

3.1 NIMS changes the game for telco cloud, vendor partnerships and automation

DT is establishing three organizational firsts with its NIMS project:

- **The implementation of an open, vendor-agnostic, disaggregated and horizontal telco cloud environment** that can support a major network function – IMS. The cloud can support both virtual machine (VM) and containerized workloads across multiple applications and services. Other tenant applications, such as CDF (Charging Data Function) and NG-NP (Next Generation Number Portability) are already following the initial IMS application.
- **The establishment of a co-design programme with vendor partners** to ensure that they collaborate effectively in a joint ecosystem on key issues. This is changing the nature of DT's relationship with its vendors and has meant selecting suppliers that believe in DT's radical transformation approach.
- **The introduction of full automation that extends far beyond current levels.** The automation spans test cases evaluation in the lab, software roll-out in the live network, configuration changes, VNF onboarding and capacity expansions.

Figure 3.1: Three NIMS organizational firsts are critical success factors



Source: Analysys Mason

3.2 NIMS telco cloud requirements

DT believes that achieving its radical targets requires a cloud approach that closely mirrors the best practices that hyperscaler cloud providers use to introduce velocity into their business processes. NIMS is underpinned by a state-of-the-art, horizontal cloud platform, or NFVI, that is completely decoupled from the NFs that it hosts. The NFVI is designed to run NFs from multiple vendors with high performance and no NF-cloud dependencies.

Such a vendor-agnostic cloud gives DT flexibility over its choice of NF providers. For example, in future, DT can easily replace a vendor that is causing quality issues, strengthen its relationship with vendor(s) that provide high value or introduce a new NF vendor that can bring innovation to market. DT is further reducing the possibility of vertical vendor lock-in by procuring its NFVI from a vendor that does not sell Core Network VNFs.

The operator is future-proofing its telco cloud by ensuring that it can support both VMs for workloads today and containers in future through an open-source-based virtualization stack that includes technologies developed under the umbrella of the Cloud Native Computing Foundation (CNCF).

3.3 NIMS vendor selection principles and choices

DT understood that the disaggregation and separate procurement of ETSI NFV architecture components maximizes flexibility. However, it was essential that the vendors that it selected recognized the challenges posed by disaggregation, shared DT´s vision for automation and believed in the opportunity that a radical transformation approach could bring. Vendors needed to understand that they had to collaborate on building the end-to-end solution, regardless of the component(s) that they contributed, and even if they were sometimes competing for business. DT's practice is to provide lab support for such multi-vendor collaboration, so that vendors can test the impact of the changes that they introduce on other parts of the solution and work together to resolve issues. DT also provides governance by clearly defining individual vendor roles and responsibilities within the ecosystem.

The following vendors were selected for NIMS.

- **Juniper Networks**. Juniper played an important role in the DT NIMS transformation as the prime integrator for the NFVI, systems integrator, automation architect and NFVI technology partner. As prime integrator, Juniper's software development team and global professional services organization served as a VNF-neutral advisor to help DT define, build and deploy the NIMS architecture and shepherd contributing vendors and solutions across the finish line. As systems integrator, Juniper managed the integration of multi-vendor software with new and legacy OSS/BSS systems. Juniper worked with DT to implement DT´s AOP architecture framework, including the CI/CD blueprints used throughout the NIMS architecture. Through AOP and what DT calls 'brutal automation', the entire NIMS life cycle of multiple live data centers and supporting labs was automated, including the digitization of site hardware, software and cabling into an inventory repository, as well as the automated LCM of the fixes, updates and upgrades to both the NFVI hardware and software and hosted IMS VNFs. DT selected Juniper, as NFVI vendor, to deliver and integrate the NFVI underlay and overlay for each of the NIMS production and lab environments. NIMS' cloud architecture is an integrated, horizontal NFVI platform, which can support any current or future VNF. It is based on Juniper's Contrail Cloud solution and consists of Juniper's Contrail Software Defined Networking, Contrail Insights analytics and Red Hat's OpenStack-based Virtual Infrastructure Manager (VIM). Juniper also provides the switching and routing platforms for the physical underlay network. Redundant data center gateway routers interface with the IP fabric through cloud-based firewalls, providing connectivity to the wide area network. A separate management network is provided by 'bottom of rack' switching.

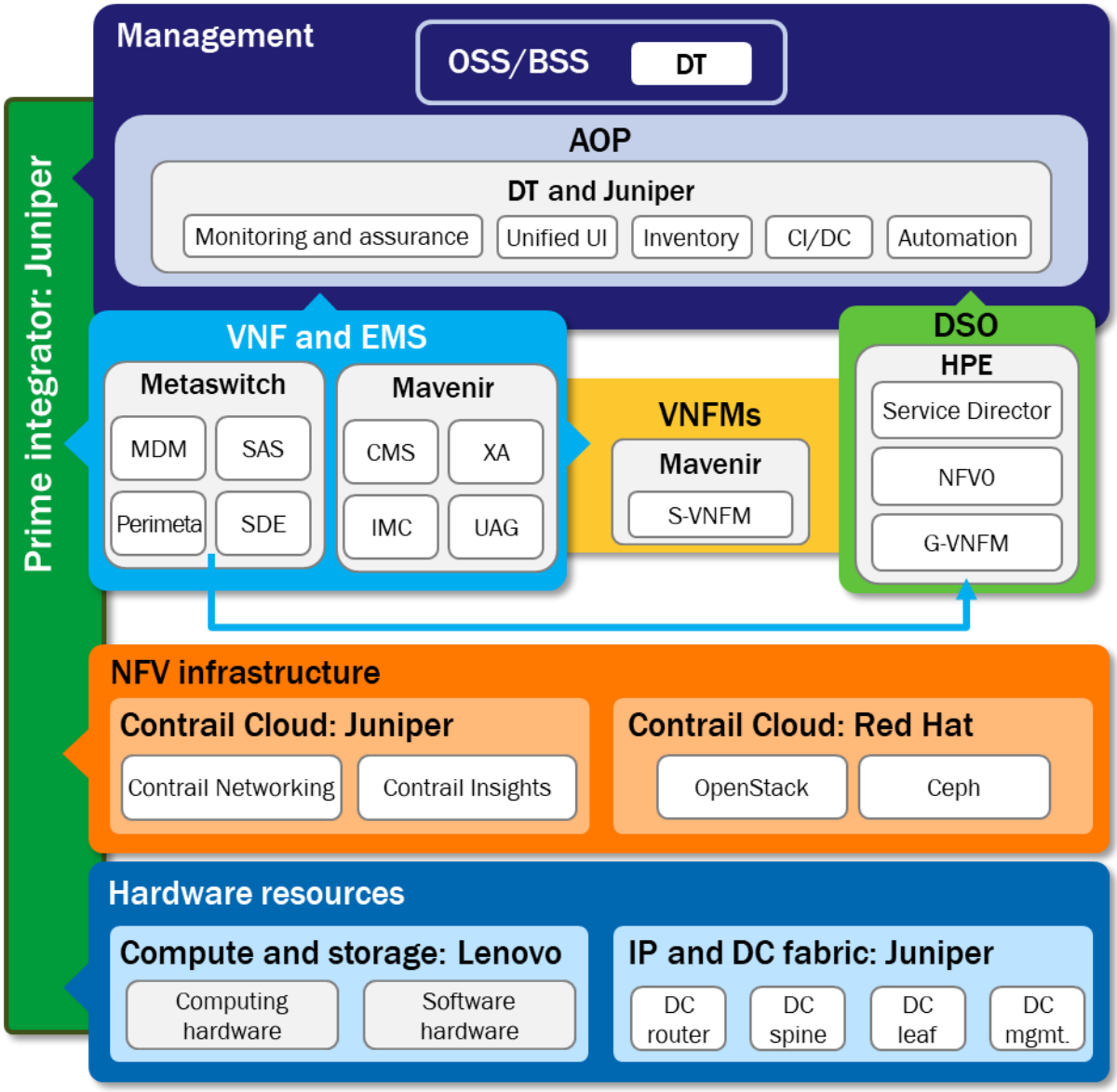
- **Mavenir** provides the access Session Border Controller (SBC) and I/S-CSCF IMS core, and **Metaswitch** provides the interconnect SBC, SIP load balancers and the BGCF in the IMS core. Although Mavenir is a known supplier to DT, Metaswitch was not, and both are challenger IMS vendors. Both companies are known for their software-only, cloud-native implementations. They understand the importance of achieving proprietary integrations into the cloud layer to sustain their performance and the primacy of code. This enables DT to understand the functions at a deeper level than it otherwise could with a 'black box' implementation, as well as to collaborate with the vendors on their operational and deployment automation, which de-risks its unconventional choice. The selection of two vendors signals DT's disaggregation strategy, which is aimed at preventing over-dependence on a single supplier.

- **HPE** delivers NFVO and domain service orchestration. The HPE solution is based on the concept of decoupling (telco cloud) resource orchestration and cross-domain service orchestration and has intent-based separation between the two levels. This allows DT to bring in an alternative or second orchestration vendor at either level if it chooses to do so. It also enables a VNF vendor to implement parts of its own orchestration functionality next to, and seamlessly coupled with, HPE's orchestration. HPE's cross-domain service orchestration capability enables it to orchestrate services that span the new VNFs and existing PNFs in DT's IMS environment (such as the Telecoms Application Server (TAS)), which are not yet at the end-of-life stage and so will not be replaced yet.

- **Red Hat** provides the virtualized compute (OpenStack Platform) and storage (Ceph) environment. DT wants to base its telco cloud on an open source-based virtualization platform that uses upstream first technologies. Red Hat brings experience of onboarding VNFs from many different vendors and an ecosystem-oriented culture. It is a key contributor to both OpenStack and Kubernetes communities, enabling it to support both VM and container-based workloads within the same platform.

- **Lenovo** supplies server hardware. Lenovo is an existing supplier to DT, including to other cloud initiatives within the company. It brings credentials around high-performance computing and high reliability to a project with stringent availability requirements.

Figure 3.2: NIMS' ETSI NFV-based architecture and supplier partners



Source: Deutsche Telekom, 2020

3.4 NIMS' automation focus

Automation is the third pillar of the NIMS project and is critical to achieving its radical targets. DT had already implemented a fully automated testing framework for its existing IMS legacy business, introduced agile development principles and experimented with open-source and CI/CD components. Based on its early experiences, market analysis and discussions with other Tier-1 operators, DT built its 'NIMS vision' for automation and created the Automation Operations Platform (AOP) to fulfil this vision.

DT created the first AOP and CI/CD blueprints in its labs in mid-2019, alongside selecting its vendor partners. DT used the AOP blueprint and its Technical Process Architecture, which comprises NIMS goals, framework and governance requirements, in its VNF/NFVO vendor RFQs.

AOP uses the cloud best practice principle of 'immutable infrastructure' but also allows for a level of 'Day 2' closed-loop monitoring and healing of individual NIMS components according to tightly defined rules that are

designed to prevent configuration drift. The CI/CD pipelines drive major changes/updates/upgrades into the NIMS environment, for example, when a change is needed that cannot be addressed by closed-loop automation. Such changes require the complete rebuild of the environment at site level from a clean set of images, in effect 'resetting' the NIMS environment and aligning it with the system inventory. However, such site rebuilds take time, so this approach is overkill for the many minor adjustments that can be made in real time by the lower-level, closed-loop automation under the governance of the MANO stack (NFV Orchestrator, VNF Managers and VIM). Such small, bounded operational changes do not have to be reflected in the AOP inventory, although they are visible through the platform's extensive visualization dashboard, as described below.

AOP consists of the following components.

- **NFVI automation**. This includes the automation for Day 0 deployment of the infrastructure clouds, deployed in multiple sites, and its management clouds deployed at several sites. This also includes deployment of underlay services such as DNS, NTP, and other fundamental server and security services.

- **The complete set of CI/CD pipelines.** Includes the pipelines that drive the Day 1 lifecycle management (including configuration and change management) of the payloads delivered on top of the NFVI, and the common toolchain that supports the pipelines. The pipelines apply functional rules such as placement and anti-affinity rules and performance requirements, but they can also be parameterized. The pipelines span the NIMS sandbox (into which vendors continuously deliver early software releases), through to the various stages of lab testing and into continuous delivery and deployment in the production telco cloud. AOP and orchestration components are also subject to the same automation goals and CI/CD through labs and into the live management sites.

- **Monitoring, telemetry and analytics**. Every component within the NIMS architecture produces telemetry data, which is aggregated for assurance purposes: Juniper's Contrail Insights (formerly AppFormix) and specific alarm collectors are used for this function within AOP.

- **Domain Service Orchestrator (DSO).** This is the overall orchestration environment for AOP that encompasses ETSI MANO-compliant service and resource orchestration. This also integrates operational automation, such as delivery through the CI/CD pipelines and assurance and inventory functions that are not part of MANO orchestration. DSO provides ETSI NFV-compliant integration with the primary MANO components delivered by HPE Service Director and NFV Director.

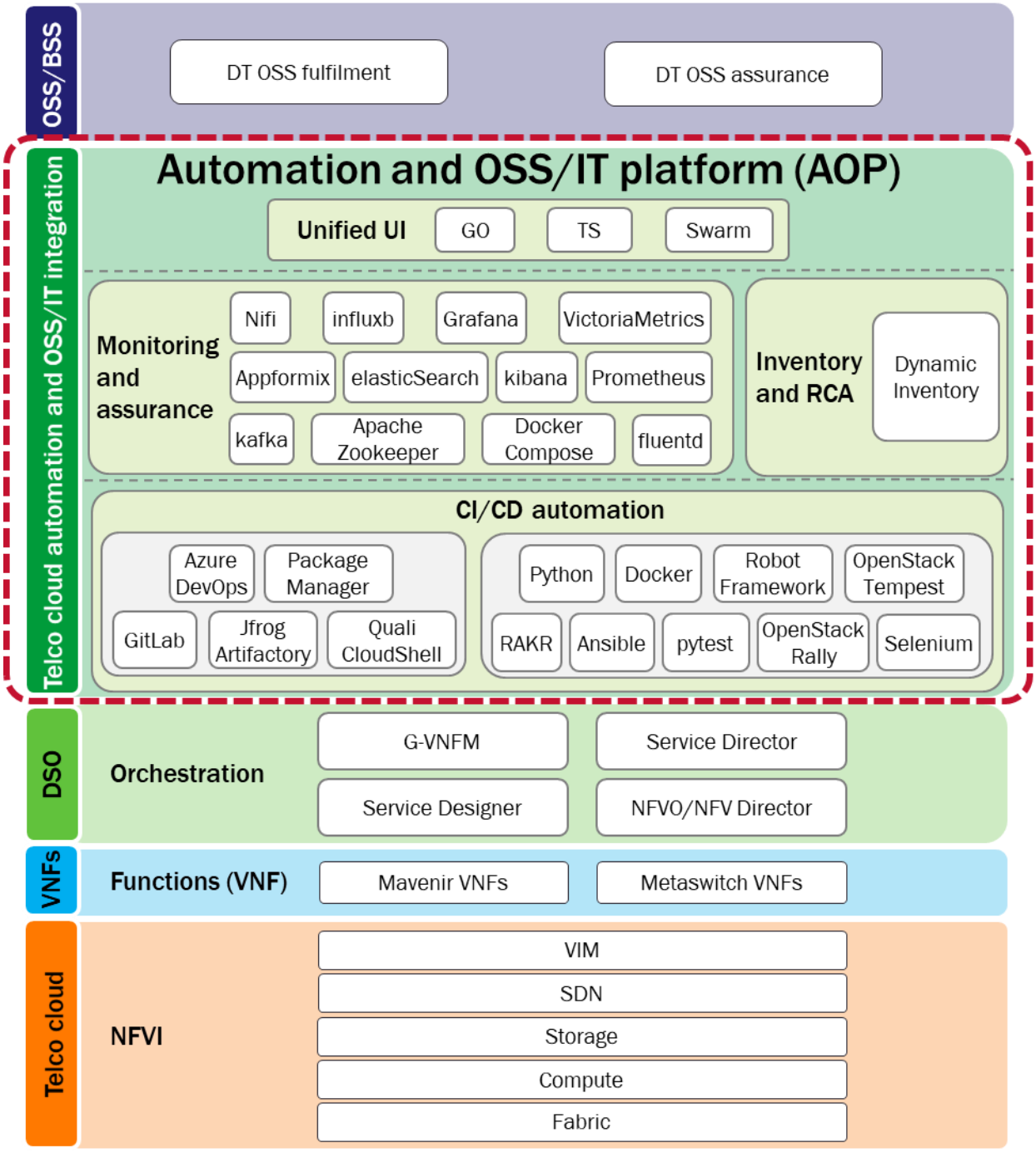
- **Inventory**. This includes Netcracker inventory components and off-the-shelf components that are already a part of DT´s application landscape. Instances sit in each data center, capture, managing and correlating physical and virtual assets. The inventory will influence DSO/MANO orchestration decisions in some cases.

- **Unified UI**. This is the command-and-control dashboard for the platform, with an instance in the lab as well as the operational live management instances for the live and management sites. It is the portal for KPI monitoring and performance reporting on voice call quality, number of registrations and other metrics, as well as for alarm monitoring. In the lab, UUI provides single sign-on facilities for DT and its vendors so, for example, they can build new pipelines, enter the sandbox and trigger the appropriate stages of a CI/CD. The UUI provides a 360-degree view for all NIMS operations.

Future AOP functionality includes support for post-deployment testing using a live site designated as a canary site and the subsequent automated and incremental roll-out of tested software to production sites. This will

require the automation of the traffic steering between sites as well as of all associated orchestration, testing and roll-back functionality. This is a large task but one that is critical for meeting NIMS time-to-deploy targets.

Figure 3.3: AOP architecture



Source: Juniper, 2020

3.5 NIMS DevOps transformation

NIMS would not be able to achieve its current level of automation and visionary goals without an accompanying DevOps transformation. This transformation goes beyond bringing development and operations personnel

together under unified management. It requires an ITIL4-inspired Continuous Service Improvement process which continuously measures vendor component lifecycles against DT's '3-2-1-0' vision. The process requires the production of regular reports for each software component that details how long it takes to roll out a new release or patch, resolve issues, as well as other metrics that affect DT's ability to deliver on its time-to-market and total cost of ownership (TCO) goals. Value stream mapping is applied to identify where the vendor delivery process is holding back the achievement of, for example, the 2-day release-to-production cycle, with targets set in the next monthly iteration of component lifecycle automation for reducing delays.

The hyperscaler community is the inspiration driving DT's 'racetrack', where vendors compete to meet the '3-2-1-0' vision: DT's DevOps transformation is adopting hyperscaler service-level indicators and ways of organising effective teams. However, putting in place agile teams, cloud-native skills and an automation culture are not enough on their own. A continuous improvement process that measures everything, makes those metrics visible to all and takes action to improve them, is key to closing in on business goals.

4. Benefits and future roadmap

DT's NIMS project has achieved three best-in-industry benchmarks as a result of the approach that it has taken to the virtualization of a large and critical network function.

- **Industry-leading speed of implementation of a multivendor telco cloud supporting a major VNF.** This has taken the operator just 2 years to build.
- **A game-changing level of lifecycle automation** for all telco cloud and payload components, from Day 0 NFVI automation to Day 1 application lifecycle management. This automation supports one-click, step-by-step deployment of artefacts across end-to-end CI/CD pipelines and zero-touch, closed-loop, Day 1 operations.
- **Code-first collaboration between operator and multiple vendors in a market-leading ecosystem.** DT has created a model of multi-vendor collaboration centered on a shared sandbox environment and common, vendor-agnostic automation platform. This enables vendors and the operator to co-create together under DT's governance.

DT expects to benefit extensively from achieving NIMS radical goals in the following ways.

- **Leadership in technology innovation**. This will give DT the agility to continuously improve its voice network and to provide the best service features and quality in the market.
- **A significant improvement in time to market for new features and updates.** This will enable DT to gain a competitive advantage when launching new products and services.
- **Lower TCO** as a result of DT's disaggregated approach and highly automated operations, including eliminating night shifts for network maintenance and improving utilization of network hardware.
- **Increased operational efficiency and productivity.** This includes the ability to support rapid scale-out of the network.
- **A flexible telco cloud environment** that is applicable to all future VNFs/CNFs that the operator wishes to deploy, which will result in more-efficient use of capex and opex.

DT's NIMS approach has proven that success can be achieved by defining automation targets first and then driving the project according to those targets. This focus on operations from the outset represents a radical departure from the traditional approach that operators have taken, where OSS is an afterthought once a network technology has been selected and even deployed. Such an automation environment can be introduced incrementally – NIMS, for example, piloted its automation concepts in its data center deployments. Building automation is an iterative process that requires continuous improvement, and hence the need for well-governed mechanisms – common, automated pipelines – to deliver incremental improvements in a timely, non-disruptive and cost-efficient way without violating the robustness and stability of the live network.

As part of its continuous improvement efforts, DT and its vendor partners have established a set of co-creation programs that are running in parallel with the main NIMS development. These programs address specific issues that will help the NIMS environment to evolve in future, such as the path to cloud-native telco cloud, in which the partners are exploring the evolution towards containers and cloud-native design approaches, new telemetry

requirements, improved scaling and performance support and the application of ML/AI-based operational models beyond the application of analytics.

5. Conclusion

DT's NIMS project has demonstrated the importance of having an ambitious vision as a means of challenging the status quo within a market and an operator's own organization. It highlights the role of such a vision as a technology and organizational accelerator: this is an important requirement where cloud technologies are concerned, since such technologies are evolving quickly and operators have an urgent need to master their pace of change.

NIMS is the latest stage in a journey that began in 2015 and it has yielded a rich set of findings on which the operator has been able to build. DT experimented with a highly automated PNF environment, learned its limitations and deduced critical success factors that it has applied to NIMS. These include the need to:

- define clear targets that all parties can work towards. In DT's case, its '3-2-1-0' vision for NIMS is simple, so everyone can understand it; radical, because such targets have never before been achieved; and inspirational, because it gives the team completely new goals to aim for
- recruit participants that fully share and support this vision, particularly from the vendor community
- believe that the vision can be achieved and that failure is not an option
- factor 'brutal' automation in from Day 0, so that all program-related activities and processes are scoped with automation goals in mind and all participants follow an 'automate first' approach.

DT's NIMS implementation is leading the market in terms of the level of cloud-native, end-to-end operational automation that it has brought to its telco cloud platform within a short period of time. Once the '3-2-1-0' vision that drives the implementation is fully realized, DT will be able to claim game-changing agility in allocating and managing voice capacity in line with demand, and in bringing innovative services to its voice network. NIMS is providing a blueprint for migrating and operating further platforms and applications in the cloud and it is demonstrating the competitive advantage that can be delivered through such cloudification.

6. Appendix: Partner contributions to NIMS

6.1 Juniper

Juniper Networks is the prime integrator for the NIMS project. In this role, it also assisted with the technical requirements used in the RFP processes for VNF, and NFVO vendors. Juniper follows ETSI architecture guidelines to supply the NFVI, including physical data center deployment, data center routing and switching platforms, Contrail Cloud (a pre-integrated, horizontal cloud stack that contains Contrail SDN, Red Hat OpenStack Platform and Ceph Storage) and Contrail Insights for analytics and telemetry based on Juniper's AppFormix. Juniper (with its sub-contractors) provides the entire infrastructure – including the underlay and the overlay networking based on its routing, switching and Contrail portfolio. Juniper also ensures that all vendor products are correctly integrated with the open-source tools used by the NIMS project, including the repositories for CI/CD-driven operations (GitOps), data stores, data adapters, streaming data and analytics for network and service healing.

Juniper builds telco cloud automation and is responsible for integrating the monitoring and telemetry platforms, root cause analysis and Domain Service Orchestrator and NVFO with the AOP. Juniper developed CI/CD pipelines, which all partners are required to support, in conformance with DT's CI/CD approach. Juniper participates in the operational transformation and knowledge transfer co-creation workstream.

6.2 Mavenir

Mavenir provides the IMS core and access SBC. Mavenir's virtualized network functions are implemented in a modular way, in line with cloud-native architecture. It has separated control and user plane functions, and externalized state and supported N+1 redundancy with dynamic scaling. It has also built an extensive automation framework for Day-2 operations, which at the time, Mavenir had to implement in its S-VNFM because very few deployments had orchestration in place. However, the architecture of Mavenir's VNFM and its support for ETSI MANO interfaces enables it to work with the MANO orchestration layer, a key reason for Mavenir's selection. Mavenir also supports DT's northbound interfaces to AOP so its automation framework can process tasks specified by DT's IMS core or access AOP SBC CI/CD pipelines, such as configuration (with the ability simultaneously to upgrade and roll back config changes across multiple components) and testing using DT's AOP testing framework and tools. Mavenir participates in three co-creation workstreams: VNF OpenConfig Telemetry, Path to cloud-native workloads and Cost and performance analysis.

6.3 Metaswitch

Metaswitch is a new vendor to DT and its selection as the supplier of the interconnect SBC and the BGCF in the IMS core is a measure of how radical DT's NIMS vision is. Large Tier-1 operators do not typically choose disruptive vendors that are not known to them for critical components of their major network functions. Metaswitch's reputation is built on the market-leading cloud-native architecture of its products, including N+K resilience and decomposed signalling and media planes, and its vision for DevOps-based automation, which resonated with the NIMS project. Like other partners, Metaswitch works closely with DT on automation, DevOps and CI/CD. Metaswitch's SBC, for example, uses an HPE G-VNFM, so Metaswitch developed the automation that enables it to integrate with HPE's orchestration stack for Day-2 lifecycle management, dynamic scaling and healing and live updates. It also quickly adapted the SBC's command line interface so that it can send its metrics, alarms and statistics to AOP's monitoring function and interoperate with AOP's UI. Metaswitch participates in three co-creation workstreams: VNF OpenConfig Telemetry, Path to cloud-native workloads and Cost and performance analysis.

6.4 HPE

HPE provides domain service orchestration through its Service Director, together with NFV Director for NFV orchestration (NFVO), within DT's AOP. The former orchestrates both the physical and virtual network components that comprise DT's fixed-voice IMS network services (NS), a differently configured NS instance that runs in each of the multiple infrastructure cloud sites, and the latter works with both Mavenir's S-VNFM and an HPE-built G-VNFM (part of NFV Director) to manage the Metaswitch VNF. HPE orchestration is part of the CI/CD pipeline that controls the configuration of the VIM in a particular site on-demand, on behalf of a specific VNF component. This is a departure from the usual industry practice of preparing the VIM in advance of a VNF deployment. HPE orchestration discovers NFVI resources through the VIM and oversees the VIM's creation of an appropriate Flavor instance based on the VNF's descriptor, together with application policies, such as anti-affinity, network and scaling policies, and the implementation of specific scripts and configuration files. HPE participates in the CI/CD with daily builds and Path to cloud-native workloads co-creation streams.

6.5 Red Hat

Red Hat provides the open-source-based virtual compute and storage environment (Red Hat Enterprise Linux, OpenStack Platform and Red Hat Ceph Storage) that is preintegrated with Contrail SDN. Red Hat and Juniper have created extensive lifecycle management automation within Contrail Cloud and have collaborated to optimize their respective technology stacks to accelerate the execution of in-service software upgrades. For example, they have re-engineered procedures so that they can run in parallel, enabling clusters to be updated in a few hours rather than days. Red Hat's professional services team supported the NIMS project in automating the creation and management of different Red Hat OpenStack Platform and Red Hat Ceph Storage configurations across NIMS' multiple sites and works closely with other NIMS vendors to eliminate service impacts from NFVI operations, such as the necessary rebooting of an underlying compute node. Red Hat participates in the Path to cloud-native workloads and NFVI infrastructure standardisation co-creation workstreams.

6.6 Lenovo

Lenovo replicated part of the NIMS environment in its Raleigh, US-based lab to carry out the capacity planning for, and optimization of, the x86 servers that it supplies to the project. Lenovo established the baseline for each server based on DT's requirements for a specific version of OpenStack, Linux kernel and SmartNIC and provided guidance in terms of the capacity required to run Contrail Cloud. Lenovo incorporates highly reliable components in its servers to achieve its industry-leading 5 9s uptime performance record and uses high-quality power supplies and capacitors to reduce energy consumption. Lenovo participates in the Cost and performance analysis co-creation programme aimed at minimizing power consumption and maximizing performance as the NIMS project expands.

7. About the author

Caroline Chappell (Research Director) leads Analysys Mason's Cloud and Platform Services practice which includes the Cloud Infrastructure Strategies and Data, AI and Development Platforms research programmes. Her research focuses on service provider adoption of cloud, and the application of cloud technologies to support digital transformation in telecoms. She is a leading exponent of SDN and NFV and the potential that these technologies have to enhance business agility and enable new revenue opportunities for service providers. Caroline investigates key cloud challenges and helps telecoms customers to devise strategies that mitigate the disruptive effects of cloud and support a smooth transition to the digital era.

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