**Introduction**

Customer experience of network services – how to order them, when they will be delivered, how well and quickly they can be tailored to customer requirements – is now heavily influenced by the digital user experience forged in the Web domain. Heavy Reading research finds that the ability to turn up Layer 2-7 services and change bandwidth on demand are critical influencers of customer buying decisions. Both require operators to be operationally agile, a quality that can only be achieved through changes to the organization, processes and tools that support the delivery of network services.

Traditional network operations are ripe for transformation because they are too slow and inflexible to provide a digital user experience of the network. Operators still have network operations that are largely unautomated, resulting in long lead times for service introduction and provisioning. If operators are to become more agile, they need more automation, but not at the expense of becoming locked into long-term engagements with vendor professional services organizations.

Operators want to follow the lead of the IT world, which is using the extreme automation concepts of DevOps to cut service delivery times and enable an online user experience of IT services. DevOps needs to become “NetOps,” to reflect network operations’ far more complex task of delivering network services across multi-vendor, hybrid physical/virtual networks. NetOps needs a platform to support the automation of this task and one that empowers operators to build this automation for themselves.

There is emerging consensus around the seven core requirements for a NetOps platform. The majority of operators will no longer consider an operational system that only manages equipment from a single vendor. Support for hybrid network management is at the top of the list as operators accelerate plans to virtualize their networks. A model-driven, programmable approach to defining and deploying services is widely accepted as key to automated service delivery, and operators agree that service models should reflect both the provisioning and assurance aspects of services so that they can be managed consistently throughout their lifecycle. A NetOps platform needs to modularize its functionality and make it available through open application programming interfaces (APIs) so that it can plug and play with third-party operational systems. Finally, it should support transactionality to preserve network consistency during service provisioning and co-existence with traditional network operations so that processes and services can migrate to it over time.

This paper argues that operators should assess a NetOps platform’s capabilities in other areas, too, likely to be those that help differentiate an operator’s service delivery and provide a competitive edge. For example, the quality of a platform’s graphical user interface (GUI)-driven support for defining service and device models without coding will determine how fast and empowered operators are to build their own automation. The ability to add rich business and network-level policies to tailor provisioning to specific customer and network circumstances increases provisioning flexibility. The scalability of a NetOps platform and its performance across large, geographically dispersed networks will be critical and will determine the quality of the real-time network visibility it can provide. The paper concludes that operators need to understand the scope of and differences between NetOps platform candidates to ensure they have future-proof support for network operations in a digital services world.
A New Experience for Connectivity Services

When Digital User Experience Meets the Network

The experience we are all used to when buying online is catching up with the communications industry. Customers increasingly expect to purchase Layer 2-7 connectivity and network services online, have them delivered on demand, and be able to flex those services as needed. A recent Heavy Reading report on Carrier Ethernet services finds that rapid turn-up of services continues to be regarded as a critical influencer of customer buying decisions. It also reports that the ability to change bandwidth on demand is bounding up the influencer rankings (see Figure 1).

Such customer purchasing criteria are, in part, a response to a new speed of business, which is affecting every industry, but they are also a result of customer expectations, groomed by the digital user experience they enjoy in other domains.

Rapid and flexible service delivery are key facets of service agility, which is frequently cited in Heavy Reading research as the top driver for network virtualization. However, virtualizing network functions won’t, on its own, deliver a digital user experience. This can only be achieved through operational transformation – changes to the organization, processes and tools that support the delivery of connectivity services. Such changes must be applicable both to the virtualized and physical network since operators have heavy investments in existing physical Layer 2-4 network infrastructure that are unlikely to be wholly displaced by software-defined networking (SDN) and network functions virtualization (NFV) any time soon.

Operators are proceeding with operational change and virtualization on a network domain-by-domain basis. The transport domain is a particular area of focus because connectivity services are of fundamental importance to a telco business. They are a growing source of revenue in their own right and key enablers of mobile network services and digital services, including IPTV and cloud. Operators are bringing in operational change to transform connectivity service delivery from the traditional weeks and months to digital era minutes, for example.
Traditional Network Operations vs. "NetOps"

Network operations – the critical network engineering organization that translates product management service designs and IT department fulfillment plans into implemented services in the network and then manages them – is under the spotlight as a key area for transformation. Network operations today are a barrier to achieving a digital user experience of the network. The IT world has already begun to transform IT operations, using the concept of DevOps, to create a digital user experience for IT services. The hallmark of DevOps is the ability to make frequent, real-time changes to production services, leveraging extreme automation. Network operations need to become “NetOps,” acquiring the same capability in order to cut service delivery times and enable an online user experience. Like DevOps, NetOps needs appropriate processes and tooling to support its automation requirements. Unlike DevOps, NetOps has to deal with a far more complex environment: the hybrid physical/virtual network.

Operators have tried numerous approaches to automating network operations over the years. Such approaches have proved complex and expensive and have often left operators locked into long-term engagements with vendor professional services organizations. The majority of operators still have network operations that are unautomated or partially automated, relying on paper-based processes, manual manipulation of command line interfaces (CLIs) to network devices, manual updates of inventory systems and armies of network device activation specialists. These factors contribute to long deployment cycles for new connectivity services and extended provisioning times for customer-facing service instances.

Figure 2 contrasts key features of traditional network operations with NetOps. A key prerequisite for NetOps is the extraction of the deep knowledge of connectivity services and network devices currently in the heads of engineers and/or on paper and its representation in a form that they can programmatically manipulate. This enables network operations to automate service onboarding and provisioning processes without professional services help.

**Figure 2: Traditional Network Operations vs. NetOps**

<table>
<thead>
<tr>
<th></th>
<th>Traditional Network Operations</th>
<th>&quot;NetOps&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network/service knowledge</td>
<td>In heads of engineers</td>
<td>Captured in programmable form (e.g., service models)</td>
</tr>
<tr>
<td>Skills level</td>
<td>High, requires detailed knowledge of specific vendor devices</td>
<td>Low, no specific device knowledge</td>
</tr>
<tr>
<td>Extent of automation</td>
<td>Minimal</td>
<td>Pervasive</td>
</tr>
<tr>
<td>Support for automation</td>
<td>Professional services-controlled automation</td>
<td>Network operations-controlled automation</td>
</tr>
<tr>
<td>Support for transactional network changes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Support for network virtualization</td>
<td>Retrofitted, adding complexity</td>
<td>Natively supported with appropriate automation</td>
</tr>
<tr>
<td>Time to launch new services</td>
<td>Months</td>
<td>Days/Weeks</td>
</tr>
<tr>
<td>Time to provision new service instance</td>
<td>Weeks</td>
<td>Minutes</td>
</tr>
</tbody>
</table>

Source: Heavy Reading
Requirements for a NetOps Platform

Core Requirements
Operators know that they must empower network operations with NetOps tooling that enables the organization itself to automate the lifecycle management of connectivity services. There is emerging consensus around the seven core requirements for such a NetOps platform. Its must-have capabilities comprise support for the following.

Multi-Vendor Devices
Layer 2-7 services typically run end-to-end across heterogeneous network environments, with devices supplied by multiple vendors. Network virtualization is likely to add vendor and device complexity as it becomes easier and faster to bring in and replace virtual network functions (VNFs) compared with physical devices. Operators expect to broaden the number of VNFs in their networks to support new Layer 2-7 services and service features, so it is essential that a NetOps platform can automate the management of end-to-end services across network elements supplied by any vendor.

Hybrid (Physical/Virtual) Networks
The evidence is clear that the NetOps platform must be able to activate customer-facing services end-to-end across the network, regardless of whether network elements are physical or have been virtualized. Leading operators have aggressive plans to virtualize the transport domain, but most recognize that it is likely to consist of physical and virtualized devices for the foreseeable future. This means that the NetOps platform must be able to interface with VNFs and physical network functions (PNFs) in the way such devices expect, whether interaction is carried out using directly using the NETCONF protocol, or via an SDN controller, NFV management and orchestration (MANO), existing operations support system (OSS) adapter layer or traditional CLI.

Standards-Based Modeling of Services & Devices
Service modeling in a standard data modeling language is key to extracting deep network knowledge and experience out of the heads of network engineers and into a form that can be programatically manipulated and automated. A key aspect of NetOps service modeling is that connectivity services should be described at an abstract level that removes any dependencies on underlying network elements/resources (PNFs or VNFs). This gives operators flexibility over where and how to provision services in a hybrid, multi-vendor network environment since service model instances bind to resources at runtime to fulfill a customer service order.

Operators have typically contracted vendor professional service organizations to create service models and automated workflows, but a NetOps platform must provide tooling that enables network engineers to create these for themselves. In the Layer 2-4 domain, YANG is emerging as the favored service modeling language because of its rigor, which suits a carrier-grade environment, its status as a standard and the fact that YANG is also used to model network devices and their management requirements. This enables YANG service models to talk directly and, in an automated way, to YANG resource models using its associated protocol, NETCONF.

Service Lifecycle Management
The NetOps platform must be able to support the lifecycle management of end-to-end services, not just their provisioning requirements. NFV has highlighted the importance and interdependency between fulfilment and assurance in a dynamic
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network environment. Services subject to frequent, on-demand changes must be immediately assurable in their new configurations, without the need for specialist integration work or time-consuming data transfer to an external assurance system. This mandates the convergence/pre-integration of fulfilment and assurance in the same NetOps platform and the development of service models that comprehend, not only the configuration requirements of service instances, but also their needs in terms of monitoring and assurance metrics.

Modularity of Platform Function

The NetOps platform must be built in a modular way so that it is easy to plug in new features and to support existing and new third-party capabilities, such as OSS systems and SDN controllers with which the platform must liaise. Strongly associated with modularity are open APIs, as these are the means by which new features/capabilities can talk to the rest of the functionality within the NetOps platform. For example, in order to populate its end-to-end view of resources in the network, the NetOps platform may need to talk to third-party inventory systems or retrieve information from third-party activation systems, including SDN controllers, to ensure the correct provisioning of an end-to-end service.

Transactionality of Network Changes

It is imperative that changes to the network are carried out in a controlled manner, preserving network consistency and integrity. The automated provisioning of an end-to-end Layer 2-4 service may involve the activation of hundreds of devices across the network and complex interactions between the NetOps platform and external systems, such as the NFV MANO and SDN controller. The NetOps platform should support the concept of transactionality so that a service provisioning transaction can be rolled back correctly in the event of failure in one of its steps.

Coexistence With Traditional Network Operations

Operators will introduce NetOps into brownfield network environments alongside traditional network operations. They will not rip and replace established OSS and years of investment in provisioning scripts and templates. Heavy Reading research finds that operators are highly reluctant to disturb OSS because of the mission critical nature of network operations and the huge levels of complexity within the OSS environment. Operators must implement a NetOps platform in as frictionless way as possible. The platform will therefore need to accommodate an operator’s:

- Current ways of working, for example, network engineers that go directly to device CLIs to make changes. The NetOps platform needs to detect such changes and update its view of network resources and their configurations accordingly, harmonizing virtual private network (VPN) name references and raising alarms if actions taken by individuals/third-party OSS have implications for the platform. Over time, Heavy Reading expects the NetOps platform to take on an increasing share of operational activities so that operators can retire existing OSS and their associated manual processes as they reach end of life.

- Existing services that may have been manually deployed into the network and that are supported by other provisioning systems. The NetOps platform will need a means of discovering these services and the devices that support them and of helping operators to create formal service models with the correct configuration and assurance parameters so that they can be automatically managed by the platform in future.
Differentiated Platform Capabilities

Candidate NetOps platforms support most, if not all, of the seven core requirements. However, there are further capabilities that differentiate platforms in terms of ease of use and time to deliver new services, flexibility, ability to operate at high scale and real-time visibility of network services and resources.

In addition to benchmarking NetOps platforms against core requirements, operators should evaluate how far a platform provides the following:

**GUI-Based Support for Model Definition & Service Creation**

A NetOps platform, by definition, must be network engineer-friendly, enabling network engineers to model services, management capabilities and network resources without external professional services help.

This requirement is best met by GUI-based tools that support:

- The point-and-click creation of service instances across visual representations of available devices
- The modeling of those devices themselves, either in a standard data modeling language like YANG, or a powerful proprietary language that can significantly reduce the time taken to model devices while providing rich, programmatic access to all the capabilities of a device’s CLI
For example, it helps if it includes a graphical editor that supports the modeling of service and device entities, including the modeling of their management requirements, both in YANG and in the platform’s native modeling language, without the need to resort to code and/or the third-party development of adapters. Engineers should not have to program or laboriously edit large native YANG files or worry about syntax, indentation, compilation and other formatting concerns.

The toolset should support the reuse of component models in larger service models to accelerate model definition and service creation and prevent configuration errors. The same modeled entities should be able to be attached to an unlimited number of service models in a wide variety of combinations where they can be modified at runtime without coding or scripting. Service models should be able to encompass, interchangeably, devices described by YANG data models and those defined using the platform’s native data modeling language. The two types of device models should be able to be used interchangeably to deliver a service, with an operator able to swap them in and out at runtime without affecting the operation of the service or the configuration of the network.

The GUI-based toolset should also make it easy to define complex and operator-specific service lifecycle management actions without coding. Where these are not supported by YANG, they will need to be expressed through the platform’s native data modeling language.

**Figure 4: Service Model Composition & Instantiation**

![Service Model Composition & Instantiation Diagram](source: Atrinet)

- **NetOps** organization models service components, network resources and associated business/network-level policies using YANG and/or native data modeling language
- **Data Model Abstraction Layer** enables model-driven network abstraction
- Each service model can be comprised of YANG or native-based models (Hybrid Service Model)
- Network configuration changes are applied in an atomic transaction through the relevant SBI APIs regardless of the type of data model used.

**Rich Policy Management**

The platform should also support the modeling of business and network-level policies to drive automated service provisioning. Service models give network engineers significant flexibility when it comes to instantiating, modifying and deleting them for individual customers. However, one of the objectives of a NetOps platform is to
lower the skills levels required for network operations so that operators need fewer highly skilled personnel to operate the network and can free them up for more valuable tasks, such as service modeling.

This means the NetOps platform must have safeguards in place to prevent network engineers from configuring models in a way that compromises the network and/or the customer experience. The NetOps platform needs to enable experienced network architects to set network-aware and/or business policies at a fine-grained level to guide the actions of network engineers. The platform should be able to support both the automated application of policies and the use of prompts that require manual intervention during provisioning.

**Active Inventory**

The active inventory provides visibility of services and resources across the multi-vendor/hybrid network and acts as the single version of the truth for service lifecycle management activities (fulfillment and assurance). The active inventory need not hold information about all network resources itself; it can use its open APIs to federate with other sources of information, such as third-party inventories and PNF/VNF management systems.

Operators can start off by using the NetOps platform’s inventory capability to provide visibility of the resources directly under its control and extend it to resources managed by other systems over time. The NetOps platform will need a robust and automated, near-real-time resource configuration discovery mechanism in order to maintain consistent and complete visibility of the network as it evolves.

**Track Record of Operating at Scale**

NetOps platforms are new, and many are untried at very high scale. A NetOps platform for Layer 2-4 connectivity services must be able to support network-wide transactions across large, heterogeneous networks, including networks that span countries and continents, and contain hundreds of thousands of devices.
Conclusion

Pushed by network virtualization trends, competition and customer demands for a new speed of service, operators are taking a long hard look at the way they manage their networks. They recognize that their traditional approaches are unsustainable. Their current organization, processes and systems are not agile enough to support the creation and delivery of new services with a Web experience and at the cost points mastered by cloud providers.

Operators need much higher levels of service delivery automation, but they also need autonomy – the ability to automate their operations themselves without recourse to an expensive vendor professional services organization. This is leading to demand for a platform that applies DevOps principles, such as the ability to make frequent changes to a production environment using extreme automation, to service and network management.

There is broad industry agreement on the key requirements for a “NetOps” platform and their need to reflect the multi-vendor, hybrid physical/virtual nature of the network today. Operators can choose from a growing number of vendors addressing automation in the network operations domain. They will want to compare solutions against the checklist of key requirements as different vendors support these in different combinations. But they should also consider carefully what differentiates these solutions.

If operators are significantly to accelerate service delivery, they not only need a model-driven, automated solution that doesn’t require the creation of complex code and scripts, they need one that is exceptionally easy and fast to use. The solution should support, through GUI-based tooling, rapid development of service and device models. The leading solutions today, especially for the transport network domain, support the YANG data modeling standard.

However, since YANG has not yet been adopted across the industry as the only means of modeling services and devices, there is room for alternative modeling languages that can add flexibility to the definition of services, for example, in the area of rich business and network-level service policies that are currently not well-supported by YANG. Models/features defined in such languages should be able to interoperate with YANG dynamically to give NetOps organizations maximum agility. Operators should look for evidence that a NetOps platform has been deployed at high scale and that it has the active inventory needed to underpin the full service lifecycle, including model-driven assurance.

It is increasingly clear that a NetOps capability is critical to network operators’ future competitiveness. Operators’ choice of NetOps platform will determine the extent of their success.
About Atrinet

Atrinet (www.atrinet.com) is a leading provider of carrier-grade, vendor-agnostic service orchestration solutions for legacy and virtual networks. Atrinet's software products enable network operators to control and optimize their network resources and streamline the service provisioning. Atrinet provides skilled and cost-efficient network management and maintenance services to over 70 customers worldwide. The company's solutions are installed in Cox, Orange, Vodafone, France Telecom, T-Mobile and Telefónica, among others.