

Accelerate Service Delivery with Network Service Orchestration

Executive Summary

IT teams face unprecedented challenges to support dynamic application requirements on top of a rigid legacy infrastructure. A vendor-agnostic orchestration helps deliver rapid network services for multi-vendor infrastructure. Anuta NCX platform with its layered, YANG model-driven and abstraction approach helps in delivering vendor neutral, extensible and maintainable services for multiple domains such as Branch/CPE, Data Center, Cloud, and Carrier Core networks. The NCX platform enables customers and partners to develop their own Service and Device models for complete customization within few days. Many large enterprises and service providers have deployed NCX to orchestrate their brownfield and greenfield networks.

Business Challenges

Today's IT infrastructure team must become a service delivery organization. Business units require agility to match that of public cloud while the IT budgets continue to shrink. Server and Storage virtualization has proven their value with automation, but the underlying **networking is manual** due to complex legacy infrastructure. Traditionally, IT teams chose best-of-breed appliances from multiple vendors each with its own management complexity. **The manual process is expensive, delays time to deployment, introduces human errors and lacks consistency.**

There have been numerous new approaches such as Software Defined Networking (SDN) to solve the network automation challenge. However, these approaches **can't introduce programmability for the existing infrastructure** built over long time without any standard practices. Hence, any custom off-the-shelf software will not be sufficient.

There are many incomplete paths to network agility

SDN: Introduces a central control plane to manage hundreds of fabric elements in a greenfield data center switching closet. SDN controllers such as Cisco ACI, Nuage VSP, VMware NSX solve a subset of operational problems such as image upgrades, spanning tree convergence, micro-segmentation, application profiles. These SDN controllers have a REST API and can be automated with tools such as Chef and Puppet. However, SDN controllers don't integrate with existing multi-vendor infrastructure and their scope is limited to Access layer in data center. Implementing SDN controllers is a first bold step towards virtualization, but a successful implementation requires much more.

SD-WAN: Introduces central control plane to manage thousands of remote branch devices for greenfield deployments. SD-WAN controllers use intelligent routing to minimize MPLS expenses while taking advantage of the inexpensive internet connectivity. However, each remote branch has multiple devices behind the CPE which require manual configuration. All the leading SD-WAN controllers require investment in proprietary overlay protocols implemented on new

platforms that are yet to prove their scalability, security, availability and performance. Meanwhile, the IT team still needs to configure thousands of existing legacy devices manually.

Network Automation: Over the years, IT teams built hundreds of templates and static scripts to automate repetitive operations. The scripts were written against a specific vendor platform using a specific software version. As soon as the underlying infrastructure changes, the scripts break. The scripts can't keep up with new technologies such as Fabric Path, Port Channels, micro-segmentation etc. The scripts don't provide any API and hence every new extension or integration results in a new automation project. IT teams are supposed to run networks, not manage the scripts. Once the developer leaves, the automation project fails and you are stuck with islands of automation. Invariably, IT teams resort to manual process thus defeating the original purpose.

The Ideal Solution

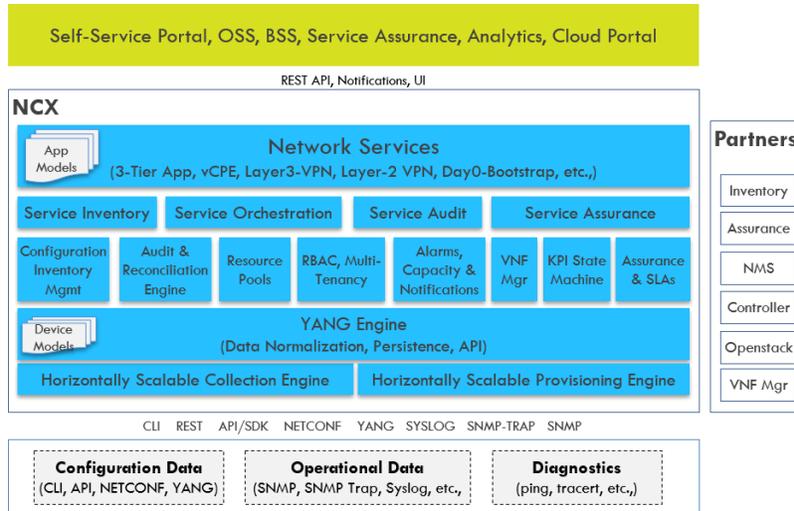
The solution requires a platform approach that is cross-domain, vendor agnostic, extensible, modular, scalable and maintainable. The solution should allow admins to express network policy along with the required SLA. To enable rapid development, the solution should **abstract multi-vendor infrastructure** by absorbing differences in syntax. The solution should have essential features such as **Service Chaining, VNF management, transaction atomicity, REST API integration, auditing, horizontal scalability, Role Based Access, Multi-tenancy, Compliance, Service Discovery**. These features help deliver a lasting solution that supports today's and upcoming micro-services based applications.

A successful solution doesn't just stop at provisioning but also **ensures consistency of the network infrastructure**. The admin needs complete confidence that the policy in the software matches the device configuration all the time.

Finally, IT teams are averse to introducing multiple automation solutions for various network segments. Any solution that provides comprehensive automation across Data Center, Remote Branch Networks as well as Campus/HQ **avoids islands of automation**.

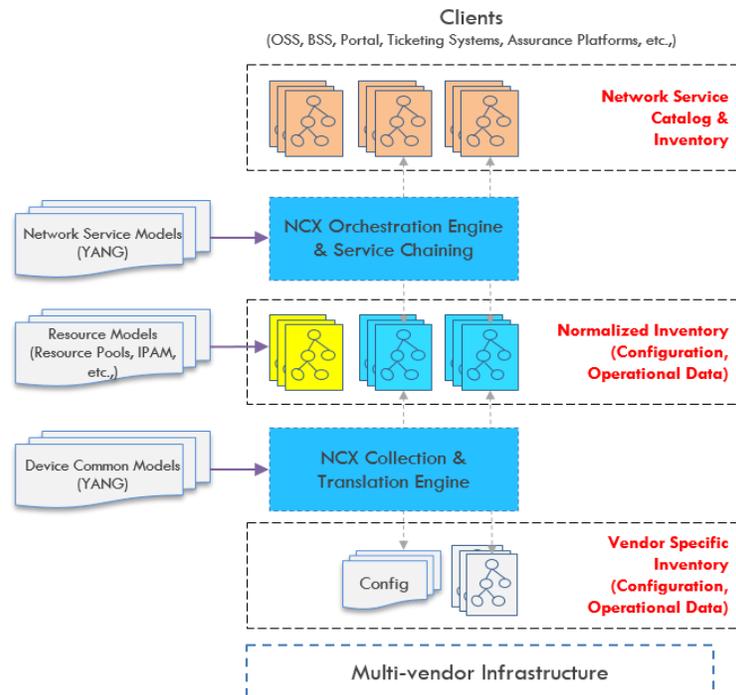
NCX – Multi-Vendor Network Service Orchestration

Anuta NCX delivers network service orchestration for greenfield and brownfield deployments. NCX is an intent-driven platform with YANG service models for multiple domains such as Branch/CPE, Data Center, Virtual MPLS, Carrier Core Networks and Cloud Interconnects. NCX has built-in YANG device models for PNFs and VNFs from 35+ industry leading vendors supporting hundreds of L2-L7 network functions using CLI, NETCONF, YANG, REST and SNMP. For a complete list: <http://www.anutanetworks.com/managed-devices/>.



NCX is integrated with leading SDN controllers such as Cisco ACI, Juniper Contrail, HPE DCN, Nuage VSP as well as northbound portals such as OpenStack, VMware vRealize, Science Logic and OSS/BSS using REST API.

NCX also integrates with enterprise software such as license managers, certificate managers, CMDB, Log Managers, performance monitoring, assurance and auditing systems.



NCX abstracts the device syntax from the service logic. The admin can define the service using YANG model including the required workflow, the Key Performance Indicators (KPIs) to monitor as well as the corrective actions in case of SLA violations. NCX has out of the box service

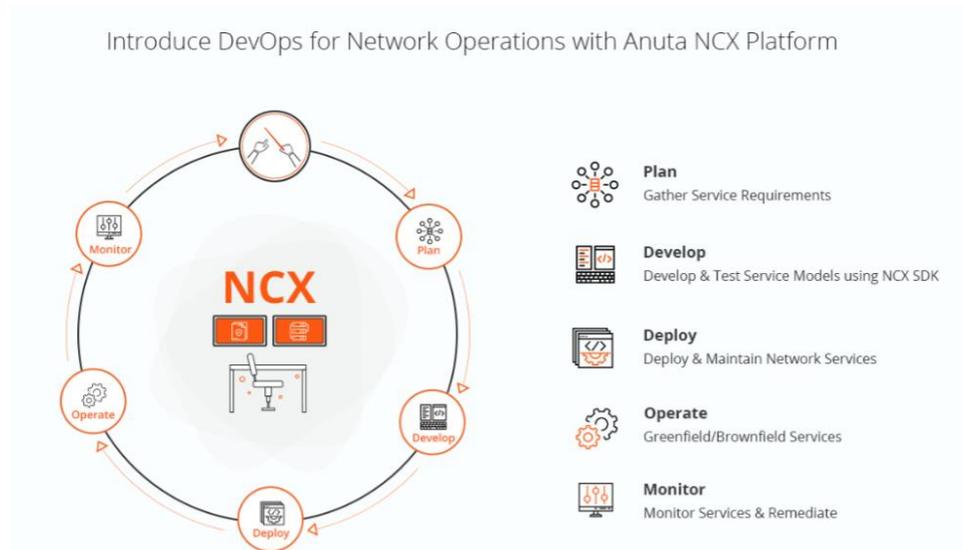
models for most frequent services such as On-boarding Applications in Data Center, On-boarding new users to campus networks, Zero Touch Provisioning (ZTP) in Branch, SD-WAN, Virtual CPE, DCI, L3 VPN, MPLS VPN, Mobile backhaul. The IETF also published many standard YANG service models that can be imported into NCX.

The Service Models can be further customized using business logic in Python or Java within hours to few days. The business logic is written as per the normalized device model. Hence, the DevOps engineer is shielded from the syntax variations across multiple vendor equipment.

NCX provides concrete mappings (also known as Device Models) for 35+ different industry leading vendors and 100+ platforms. The device models can be extended using YANG within days to couple of weeks depending on the complexity of changes. In the future, when a vendor publishes YANG models for their device, NCX can use them instead of developing concrete mappings.

Service Agility with DevOps

DevOps enabled faster delivery for Server Provisioning by treating infrastructure as code. You can bring the same agility for Networking. Anuta NCX platform helps introduce DevOps for networking.



Plan: Product Managers and Network architects can describe the service they want to offer on their infrastructure. They can use built-in Service Models (starter kits) to describe various network services such as L2 VPN, L3 VPN, IWAN, App Delivery etc. NCX also provides service model framework using which you can extend these starter kits with SLAs.

Develop: DevOps teams can take the starter kits, introduce business logic, workflow and integrate with 3rd party software in the infrastructure. NCX also provides a normalized network model. The developers don't need to know semantics of individual vendor devices. NCX

simplifies the task for devops team so they can develop common code base that works for multiple deployments. NCX provides development tool kits, code generators to automate majority of this task. DevOps can customize for various vendors and use-cases, introduce versioning, release management to infrastructure using YANG models.

Deploy: NCX provides lots of operational support including Packaging & Versioning, Integration into Ecosystem, Upgrades & Maintenance

Operate: NCX has smarts to discover infrastructure, brownfield service discovery and has vendor plug-ins. NCX can scale horizontally. NCX introduces self-service through GUI or comprehensive REST API and integrates with ticketing systems. When someone orders a service, the whole service chaining happens automatically. NCX uses service models and device models to auto generate commands and executes workflow. NCX Introduces self-service and on-demand provisioning to the network infra and avoids inconsistencies & human errors.

Monitor: NCX constantly monitors the infrastructure through audit and reconciliation. NCX validates policy against infrastructure to provide better visibility for SLA assurance. NCX maximizes infrastructure utilization.

High Level NCX Features:

<p>Resource Discovery and Resource Pools</p>	<p>NCX discovers the existing physical and virtual network infrastructure consisting of multiple vendor devices. The discovery engine identifies device type, device role, device capacity as well as connections with remaining infrastructure. Based on this information, NCX builds the network topology and inventory. Administrators can organize the discovered resources into multiple pods and resource pools for service provisioning.</p>
<p>Service Packages</p>	<p>NCX has out of the box Service Models for multiple use cases such as Application Delivery in Private Cloud, Physical, Virtual and Hybrid CPE, Campus Segmentation, Data Center Interconnect, IP/MPLS backbone, Virtual Appliance Lifecycle Management, Metro Ethernet and Wholesale Services.</p>

<p>Built-In IPAM</p>	<p>NCX includes IPAM to manage various network interconnects as well as VNFs. Admin can also manage VLANs and VRFs across multiple devices for multiple tenants.</p>
<p>Inventory – Basic and Extended</p>	<p>NCX periodically runs basic inventory to validate network availability and collects alarms. Admin can also schedule extended inventory to compare the device configurations against service policy. This real-time inventory helps NCX optimize service provisioning for effective monetization of the infrastructure.</p>
<p>Service Chaining</p>	<p>NCX executes the Service Chain as per the Service model. For example, to on-board an application, NCX generates CLI and API calls to configure the L2 switches, L3 routers, L4-L7 firewalls, load-balancers (ADC), web proxy devices etc. NCX ensures atomicity of the transactions to ensure the devices are always in a consistent state.</p>
<p>Approvals</p>	<p>As part of Service Model, admin can also define various approval sequences and integrate with external ticketing systems, OSS/BSS etc.</p>
<p>Self-Service Catalog</p>	<p>Network admins can package various service models and offer a catalog of services for tenant consumption. Using a comprehensive REST API, these catalogs can be exposed to northbound portals such as OpenStack, VMware vRealize, Science Logic as well as any customer specific portals.</p>

<p>RBAC</p>	<p>NCX offers comprehensive support for role based access control and integrates with existing identity stores such as AD and LDAP to enforce authorization policies. Roles and permissions can be customized to satisfy various organizational structures. Users can be restricted to a small set of actions, given complete control or any other variations in between.</p>
<p>Multi-Tenancy</p>	<p>NCX orchestrates multi-tenant infrastructure. MSPs and Telcos can use the same NCX software instance to automate network services for thousands of managed enterprises.</p>
<p>Device Compliance</p>	<p>NCX uses a model-driven approach to ensure compliance. At the time of installation, NCX scans multi-vendor devices and discovers previously configured services using the admin defined YANG models. Further, NCX periodically performs inventory job and validates the actual device configuration against the device state in NCX. If there is any discrepancy, NCX will generate an alarm. The administrator can either Overwrite NCX (i.e. Update the NCX state to include the current device configuration) or Overwrite Device to revert the out-of-band changes. The configuration reconciliation feature ensures that NCX state is always in-sync with the device configuration thus enabling Service Assurance.</p>
<p>Audit Logs</p>	<p>All changes in NCX are archived for audit. The audit log can be filtered based on time stamps, user name, status as well as device details. NCX GUI highlights the configuration implemented for each service request.</p>

<p>Rest Conf API</p>	<p>NCX offers comprehensive Rest conf interface, SDK and a library of Python scripts that simplify integration with northbound self-service portals such as Science Logic, vRealize Automation Suite and any other self-service portals.</p>
<p>OpenStack Integration</p>	<p>NCX supports OpenStack as VIM (virtual infrastructure manager) through northbound integration for VNF life cycle management.</p>
<p>Service View</p>	<p>NCX provides a single pane of glass for the entire service regardless of the infrastructure differences. For any given tenant, admin can view the service status, provisioned operations, current and historic SLA metrics as well as any alarms related to service health. This information is available through REST API for integration with OSS/BSS for billing purposes.</p>
<p>Dry-run mode</p>	<p>Dry-run mode in NCX allows admins to order services and preview the configuration that would be generated without pushing to the devices. The Dry-run mode enables devops to customize the service and device models as per the best practices.</p>
<p>Support for External Data Base</p>	<p>NCX saves all the device and service models as well as server state in external databases such as Oracle, MS SQL or PostgreSQL. The support for external database ensures that NCX scales linearly with number of devices. Further, NCX server can be recovered in case of a crash and restore all the services stored in the external database.</p>

<p>SDK</p>	<p>NCX SDK includes tools for Build, Package, Verification, Upgrades and Application migration. DevOps teams can take advantage of the Modeling Tools, Development Environment, Templates for Device and Service models to customize the NCX deployment.</p>
<p>Zero Touch Deployment</p>	<p>NCX manages the Day-0 configuration of remote branch routers and data center switches. As soon as the device powers up, it will download the initial config based on DHCP parameters. When the device contacts NCX, NCX will download the base template and initial policy to the device. This ZTD support avoids costly on-site visits for network operators and accelerates on-boarding of remote infrastructure.</p>
<p>Rollback</p>	<p>During Service Orchestration, if any errors are encountered, NCX rolls back all changes made during prior operations and leaves the network in a consistent pre-deployment state.</p>
<p>VNF manager</p>	<p>NCX Virtual Appliance Lifecycle manager enables administrators to customize the Virtual Appliance configuration (e.g. image management, placement), activate licenses, provision services and monitor the Virtual Appliance performance and availability. NCX can introduce new VNFs to dynamically scale-up and scale-down the network.</p>

Scalability and Resiliency

The NCX platform is built with micro-services based architecture and is delivered as a software appliance (VM) for maximum flexibility. NCX's distributed server-agent model enables orchestrating minimal to gigantic deployments ranging from 100 to 150,000 devices.

The NCX server and agent are deployed on two different VMs. The NCX server provides the administrator a central view to create business and service policies. The NCX agent is deployed closer to the network infrastructure and designed to manage the network resources including policy provisioning and monitoring. This allows NCX to scale across multiple data centers providing uniform business and network policy compliances. Multiple NCX servers can be setup in an Active-Active configuration behind a load balancer to share the load and to offer high availability. NCX servers are stateless and leverage external databases such as Oracle or SQL. The NCX server and NCX agent communicate using SSL and don't require security teams to open new ports.

Extensibility

Even though NCX works as generic Orchestrator, it has been validated with physical and virtual appliances from 35+ industry leading vendors including Arista, Brocade, Cisco, Citrix, Checkpoint, F5, Juniper, Palo Alto Networks, Radware, VMware etc. supporting hundreds of L2-L7 network functions using CLI, NETCONF, YANG, REST and SNMP. NCX supports multiple NFVI including VMware, KVM and OpenStack.

Anuta Networks routinely publishes vendor, platform and technology specific models adapted from IETF, Open Config or customer developed. NCX includes productivity and development tools as well as auto code generation tools that introduce DevOps approach to networking. Further, NCX SDK allows all device models to be developed by customer or partners. For instance, minor extensions can be implemented within hours while adding new vendor device models can take days to maximum of 2 weeks.

Service Assurance

NCX provides a single pane of glass for the entire service regardless of the infrastructure differences. For any given tenant, admin can view the service status, provisioned operations, current and historic SLA metrics as well as any alarms related to service health. This information is available through REST API for integration with OSS/BSS for billing purposes.

As part of the YANG service model definition, network architect can define SLA parameters (e.g. which interfaces and metrics to monitor). The YANG model also includes remediation steps when the SLA parameters are not met.

During service provisioning, Network Orchestrator validates the service model against the existing infrastructure and ensures capacity prior to provisioning the network elements. NCX generates commands and APIs for multi-vendor infrastructure as per the recommended best practices.

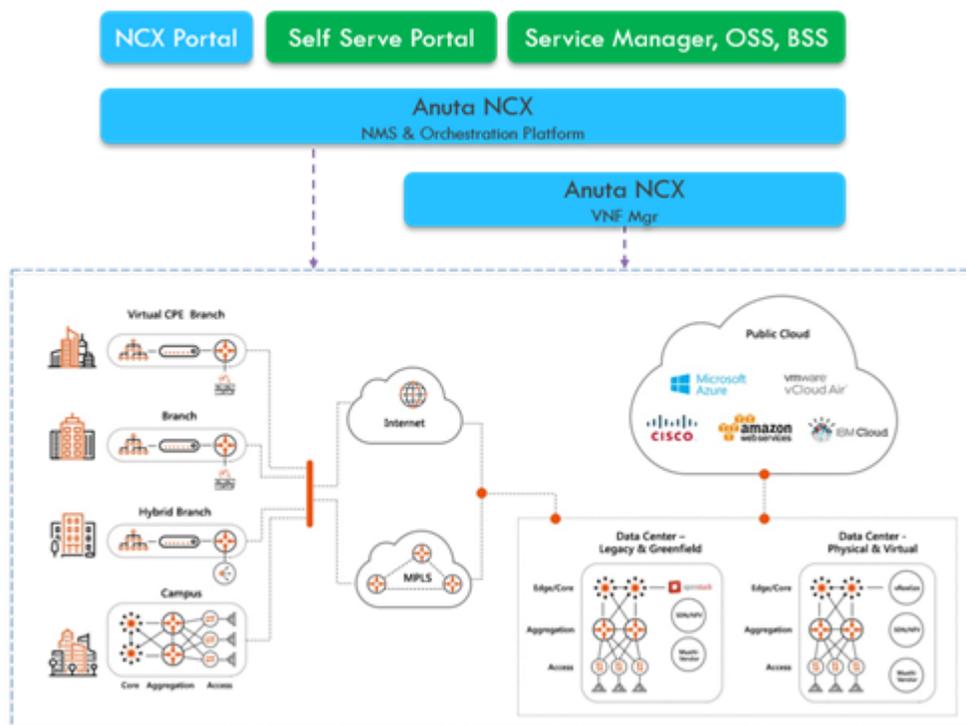
Further, these commands are sent in an atomic fashion, so if any one device fails to provision, Orchestrator will roll back the configs from rest of the devices.

After service is up and running, admin can schedule periodic reconciliation tasks. NCX uses its service model definition to discover the existing configs and makes sure the policy is consistent with underlying infrastructure.

NCX constantly collects the SLA metrics and if any parameters are violated, it executes the remediation steps to automate corrective actions as per the YANG model.

NCX Use Cases

Managed Branch Services: Multiple Tier-1 SPs and large enterprises have used NCX to offer packaged Virtual CPE to their remote branches. The vCPE included vRouter such as Cisco CSR1000v, Brocade Vyatta and HPE VSR, vFW such as Juniper vSRX, Fortinet and Palo Alto Virtual firewalls, vWanOp such as Riverbed virtual steelhead, Open vSwitch or VMware vSwitch and OpenStack. Many customers also deployed Hybrid CPE including a combination of legacy Cisco ISRs, Cisco IWAN and SD-WAN controllers. NCX automates multiple network functions such as QOS, Segmentation, Firewall policies, ACLs, IPsec or DMVPN, Policy Based Routing, Performance Routing, Deep Packet Inspection, WAN Op, Web Security and Zero Touch Deployment for these CPE devices.



Managed Data Center Automation – NCX is deployed to offer Infrastructure as a Service in large data centers for use-cases such as Firewall as a Service, Load-Balancer as a Service, On-demand provisioning of L4-L7 ADC controllers and Firewalls, Data Center Interconnect, Provisioning Virtual Data Centers for each tenant as well as integration with SDN controllers including Cisco ACI, Juniper Contrail, HPE DCN, Nuage VSP and F5 BIG-IQ.

Carrier Core Networks Automation – NCX orchestrates Virtual PE, Virtual CE, MPLS L2 VPN, L3 VPN and Cloud Interconnects using VNFs from Brocade, Cisco, Ericsson, HPE, Juniper etc.

Customer Deployments

Telstra in Australia has multiple NCX deployments including 120,000 managed CPE devices roll-out, Multi-vendor data center automation for hundreds of internal departments and cloud interconnect for 4 global sites.



Tata Communications has deployed NCX in their SD WAN project for thousand hybrid CPE devices in first phase with the plan to support up to 125,000 CPEs in next two years.

Japan Post, the Fortune-13 Global Financial Institution, has deployed NCX for data center automation in Private Cloud for hundreds of individual departments

NRI, an IT consulting firm in Japan has deployed NCX to enable hybrid WAN connectivity for 250+ customer sites.