netOps.ai

An Automation Framework

From

TECH MAHINDRA

CI.NXt

Continuous Integrator: A New Age System Integrator

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Document Ownership

Department	Last Update
CORE & Telco Cloud Solutions, Network Services	April 2020

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Introduction

Network Transformations around the globe are suffering from not being able to capitalize on automation and Site Reliability Engineering principles.

Careful evaluation of SDN/NFV transformations across the globe has shown that costs on the overall have increased, whilst overall velocity has either remained the same or in some highly unfavorable cases, decreased. Additionally, some efforts to increase speed or reduce costs have resulted in an overall degradation in quality of services provided.

Very few transformations have successfully achieved all three objectives of cost, speed and quality at the same time. Some of the primary factors attributing to this failure to achieve business objectives are:

- **Processes and Procedures do not always take care of maturity level of ecosystem:** Current day VNFs are not cloud native, maintenance procedures on infra hardware and software can have a direct impact on the service. At the current stage of maturity of ecosystem, extra care needs to be put on developing and executing standard operating procedures

- **Lack of Advanced and Appropriate Tools:** Many networks continue to use legacy tools in the Service Assurance Incident Management areas. This is attributable to not having fit for purpose off-the-shelf systems to match with the much more advanced NFV infra and VNF eco system

- **Upgrades & Patching:** Lack of comprehensive automated procedures cause unsustainably long delays in Upgrades and Patching of Infrastructure and Network Functions

- **Lack of descriptive Operational documentation:** There is generally a lack of documentation across all Operational areas. e.g. No single source of truth Network

topology and architecture view. This causes delays in debugging and RCA. Scripting and automating procedures with inbuilt code-documentation means debugging, troubleshooting etc. is much easier.

- **Insufficient Level of Certification / Testing:** Even though certification of the VNFs is carried out by the infrastructure vendors, a lot of defects still slip through to production. Automated testing & certification using CI/CD principles is key to ensuring high quality of provided services

- **Continued reliance upon OEM vendors:** Many Operators are very dependent on OEM vendors to design, implement and maintain functionality in their Network. Whilst the initial design and implementation should be carried out by the vendors, there is a need to automate and standardize operational procedures and methods so that internal teams are more confident in handling and managing the network on their own.

netOps.ai is a next generation Automation Framework that allows the implementation of an Operations Cockpit for all methods and procedures in various network domains including Infrastructure, Access, Core and Transport Networks. The Framework specifically tries to address the problem areas mentioned above and has been designed to suit all types of Operators ranging from Greenfield to Brownfield MNOs.

For an Operator who has both PNFs and VNFs already deployed in production and is now looking for having a common unified cloud platform strategy for both their Network and IT workloads and not wanting to go through another set of “trials” with unfit for purpose automation/orchestrators.

Also, for an Operator who is yet to realize their business objectives due to high CAPEX and OPEX costs along with slow speed of change and An Operator looking to leapfrog complexities of “seemingly next steps” of cloud native 5G world.

netOps.ai Framework

netOps.ai framework acts as a one stop-shop for enabling multi domain and Hybrid (Infra, RAN, Core, PaaS) automation for Network Deployment, Continuous Integration, Continuous Deployment, Continuous Test, Network Assurance and AI based Operations.

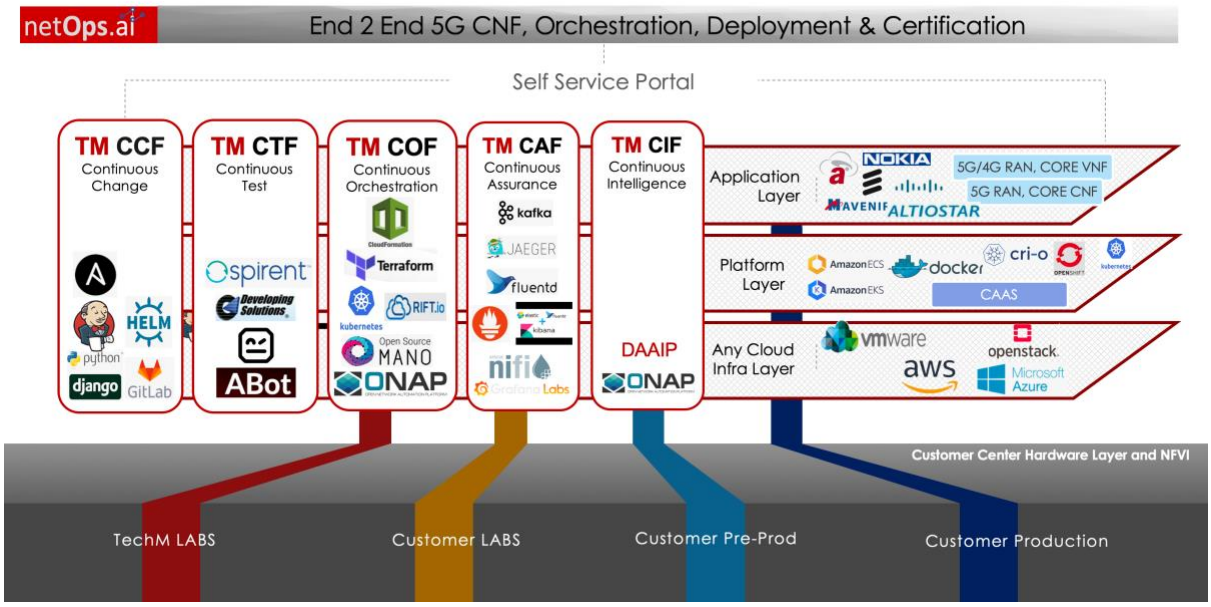


Figure 1: Five Functions of NetOps.ai

The framework acts as a common glue across multiple open source technologies like CNCF solutions and other vendor/standard bodies provided OSS/BSS systems.

Following are the components highlight:

- **Continuous Change**
  - Upload Artefacts (images, vnfd, Helm Charts)
  - Auto Release Creation
  - Auto Validation of Parallel Releases on multiple test beds and lab-line-ups
  - Integrated with E2E Slice Lifecycle Management
- **Continuous Orchestration**
  - Automated deployment of images on Cloud and Container Platforms
  - Auto Provisioning and Execution of VNF/CNF Life cycle management

  - Integrated with E2E Slice Orchestration
- **Continuous Testing**
  - Integrated with Continuous Change
  - Automated test execution and Reporting
  - Parallel Multi Test Bed Execution Management
- **Continuous Assurance**
  - E2E 5G Network Slice Assurance
  - Cloud & Container Platform, VIM Infra, Network fabric & VNF/CNF monitoring, performance & alarm management
  - Common messaging BUS to integrate any 3rd party monitoring tools
  - Single dashboard to view FM and PM
- **Continuous Intelligence**
  - Predictive insight & early capacity planning
  - Predictive Analytics attempts to provide proactive analysis of data, perform RCA, & Closed Loop
  - Identify patterns in event, resource and performance trends using AI/ML

netOps.ai Logical Architecture

netOps.ai framework blueprint has been drawn up keeping all the automation needs of networks of future in mind. The framework also takes into account the future Slicing requirements of 5G networks.

The automation framework addresses two major domains:

1. Build
2. Orchestration & Automation

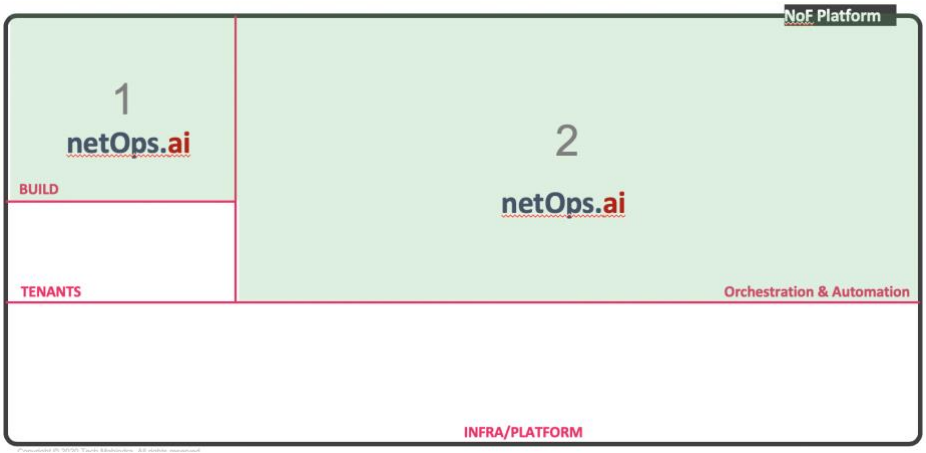


Figure 2: netOps.ai Level 1 View

The other two domains of Tenants and Infrastructure/Platform is generally addressed by OEM vendors and Infra Providers. netOps.ai is inherently designed to interwork and integrate with any tenant and any Infra/Platform.

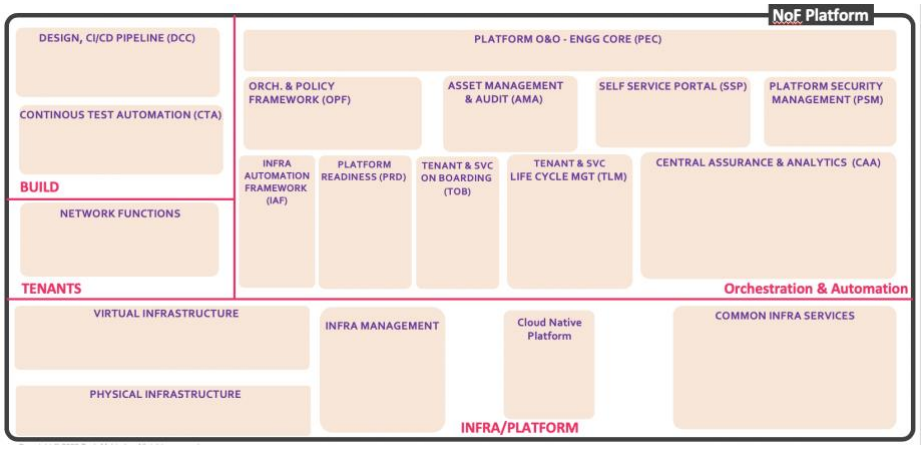


Figure 3: netOps.ai Level 2 View

Infrastructure/Platform

- Physical Infrastructure
    - Physical Infrastructure in Infra Domain consist of Hardware for compute, storage & network fabric.
- Virtual Infrastructure
    - Abstraction layer of physical infrastructure by using hypervisor, e.g. ESXi, KVM, Xen, or any Public cloud-based hypervisor, e.g. Nitro, Hyper-V.
- Cloud Native Platform
    - Containerized Platform built of docker or cri-o and orchestrated by Kubernetes (k8s), e.g. OpenShift or any Vendor's own platform
- Common Infra Services
    - All support functions that are required to NFVi and VNFs e.g. DNS, NTP, AAA, LDAP etc.

Tenant

- Network Functions
    - Network function under Tenants domain is defined by various virtualized or cloud native 4G or 5G or RAN network elements

netOps.ai Build

- DCC - Design CICD
    - CI/CD Pipeline with DevOps environment that ensure that no release, patch or change goes into production environment without validation, can have multiple pipelines as per component packages
- CTA – Continuous Test Assurance
    - Automated and continuous testing (Unit, Integration, Regression and User acceptance testing) for all netOps.ai components & Services at various levels
    - Test Governance and Control

netOps.ai Orchestration & Automation

- CAA – Central Assurance and Analytics
    - Provides functions for Tenant (VNF, EM, VNFM) and Infrastructure (Hardware + NFVi) monitoring from FM and PM perspective. It collects and injects events and surveillance data in an analytics system to develop insights and also has functionalities to carry out RCA, Service Level Management and Trouble Ticketing Interfacing etc.

- TLM – Tenant & SVC Life Cycle Management
    - This component provides functions like Tenant Provisioning i.e. instantiation of Tenant entities and managing their life cycle (Provisioning, Commissioning, Activation, Closed Loop Management etc.)

- IAF – Infrastructure Automation Framework
    - Provides a framework for IaaS and PaaS Infra Automation (Deployment and Config). It also acts as the integration layer for Orchestration to invoke IAC where required

- PRD – Platform Readiness
    - This is a set of functions that enable the whole Platform to be service ready. Various functions include Capacity Management, Config Management etc.

- PEC- Platform Orchestration and Operation - Engineering Core
    - Provides essential plumbing and implementation framework for netOps.ai Blueprint components. Will provide:
    - API Gateway - Single Point entry for all southbound communications to the micro services and gateway through which all inter-micro services communication will pass
    - Event Bus - Channel that allows independent communication between the micro services
    - Micro Services Orchestrator - For deployment and configuration of micro services

- OPF - Orchestration and Policy Framework
    - This component provides the common framework and services for netOps.ai Blueprint E.g. Catalogue, Dynamic Inventory, Orchestration and Workflow, Policy, Self Service Portal, Security Management etc., NFVO will be part of the components framework.

- SSP - Self Service Portal
    - It's a 360° single UI front-end that spans all netOps.ai Blueprint components. It is the only user interface for all operational user roles. Provide E2E view of netOps.ai components and services

- PSM - Platform Security Management
    - This component provides the end to end security for netOps.ai components. Will provide automated framework for defining security policies, their distribution and enforcement, Constant Security Surveillance, scanning, monitoring, Security breach handling etc.

- AMA - Asset Management and Audit
    - This component manages the lifecycle of all the domain functional components and assets. Asset Management ensures up to date Asset database that reflects real time assets/inventory pertaining to netOps.ai boundary.

- TOB - Tenant On-boarding
    - Serves the purpose of On-boarding Function in netOps.ai Platform
    - Updated VNF/CNF package from VNF/CNF Vendor are an input.
    - Develop Network Service Blueprint, validate, prepare the NFVI & Networking environment to the point where Production telco platform is ready to instantiate the Network Service
    - It also performs the similar resource orchestration and platform validation for container platform and prepares the CNF deployment and auto provisioning.

netOps.ai Functional Architecture

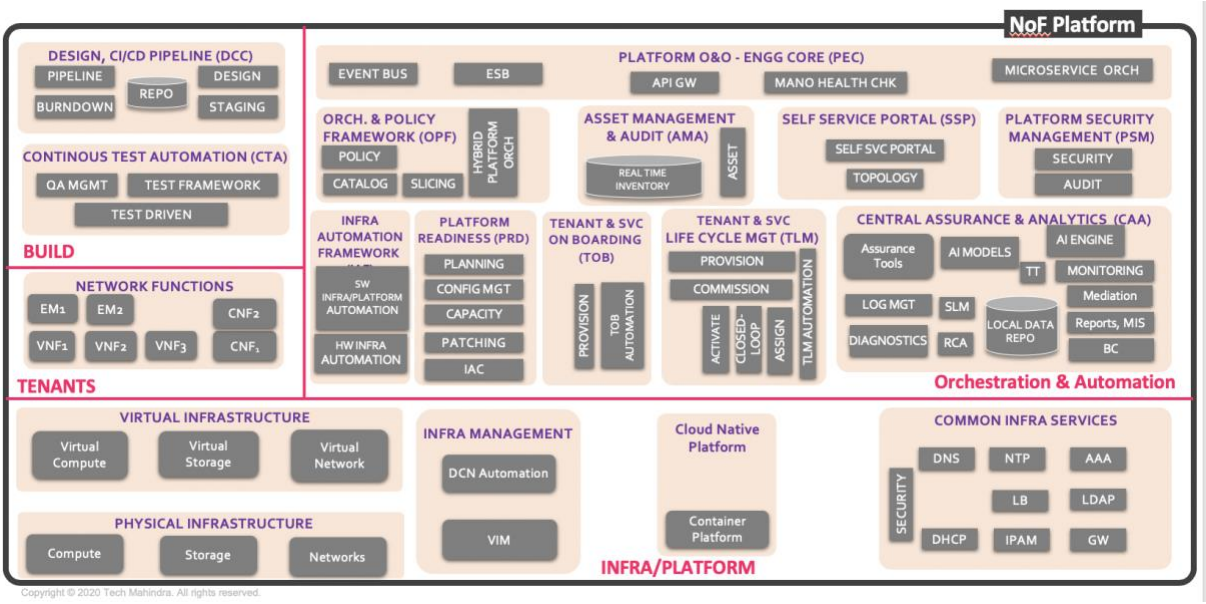


Figure 4: netOps.ai Blueprint Level 3 View

Domain	Sub-Domain	Component	Component Description
INFRA	Physical Infrastructure	Compute	Compute represents the CPU's and Cores of Physical Infrastructure
		Storage	Storage represents the disk space of Physical Infrastructure
		Network Fabric	Network Fabric represents the Network Interface Cards and Data Centre Switch Fabric (Leaf, Spine)
	Virtual Infrastructure	Virtual Compute	Virtual compute is the abstraction of physical CPU's and Cores
		Virtual Storage	Virtual Storage is the abstraction of disk space of Physical Storage
		Virtual Networks	Virtual Network is the abstraction layer of physical networking

	Infra Management	Virtual Infrastructure Manager (VIM)	The VIM is responsible for managing the virtualized infrastructure of an NFV-based solution.
		Software Defined Network (SDN) Controller	An SDN controller is an application in a software-defined networking (SDN) architecture that manages flow control for improved network management and application performance
	Cloud Native Platform	Container Platform	The container platform is built on docker platform and it orchestrated by K8s. The container platform offers very flexible, modular and compact platform that runs 5G cloud native container functions, which are mostly software centric and stateless less and small footprint software applications.
	Common Infra Service	Support Functions e.g. DNS, NTP, LDAP, AAA, LB, etc.	Components like DNS, Load Balancers, NTP, LDAP and AAA under Common Infra Services sub-domain have been used across the Telco Ecosystem verticals for functions like Domain Name Lookup, Clock Synchronization, Authentication and Authorization etc.
netOps.ai BUILD	Network Functions	VNFs or CNFs	VNF is responsible to handle a specific network functions that run on one or more VM's on top of cloud infra. The Telco Ecosystem contains multiple types of VNF and CF

			workloads from different OEM vendors which provide different network services.
		EMs	Element Manager (EM) is responsible for the functional management of VNF i.e. FCAPS (Fault, Configuration, Accounting, Performance and Security Management). This may manage the VNFs through proprietary interfaces. There may be one EMS per VNF/CNFs or an EMS can manage multiple VNFs/CNFs. EMS itself can be a VNF
netOps.ai BUILD	Design, CI/CD Pipeline (DCC)	Design	Design is a web application embedded in Self Service Portal (SSP) sub-domain which provides operational functionality of DCC sub-domain
		Pipeline	CI/CD pipeline is to enable teams to release a constant flow of NFV and VNF/CNF software updates into production to quicken release cycles, reduce OPEX and risks
		Burndown	This component provides the dash boarding in SSP about the amount of task completed in a particular Sprint
		Repo	Capability to manage the repositories for the packages (Firmware, NFV and VNF/CNF software etc.) for NFVI HW. It

			includes the necessary scripting to create, change, delete these related Art factory repositories
		Staging	This component ensures that software packages gets mirrored and tested in the CSP on premise staging environment first before deployment in production environment, staging environment should be equivalent to production) and verified.
	Continuous Test Assurance (CTA)	QA Management	This component is coupled with DCC which will ensure majority of issues gets identified at the starting of NFV and VNF/CNFs software release cycle and fixes them as cycle progresses. This will result fewer issues to reconcile at the time of final validated release for production
		Test Framework	This framework is responsible to maintain the test suites and scripts that are required to test the complete NFVI and VNF/CNF systems
		Test Driven	Test Driven component ensures to follow a short, repetitive and continuous cycle of creating unique test cases which are needed in Telco Cloud environment prior to any firmware upgrade, software release, patch upgrade etc.

netOps.ai Orchestration & Automation	Platform Orchestrator & Operation - Engineering Core (PEC)	Event Bus	- Event bus component provides a channel that allows independent communication between the micro services. - Events can be sent to the event bus by a micro service without knowledge of destination t and can be read by the destination micro service which is listening the bus
		Enterprise Service Bus (ESB)	An Enterprise Service Bus (ESB) is fundamentally a solution to integrate numerous applications together over a bus-like infrastructure. The core concept of the ESB is that we integrate different applications by putting a communication bus between them and then enable each application to talk to the bus.
		API GW	This component provides a single point of entry for all southbound communications to the micro services. Also, it will ensure that all inter-micro service communications get pass through API Gateway.
		MANO Health check	Provides micro services responsible for checking and analysing health check of MANO Subdomain, components and services provided by themselves.

		Micro service Orchestration	Responsible for deployment and configuration of micro services and ensures availability of micro services endpoints (Applicable for all **netOps.ai** MANO Components)
	Orchestration & Policy Framework (OPF)	Policy	Provides Policy Management capability – Various automation workflow and tasks definition, Policy Design/Administration, Policy Distribution, Policy Enforcement and monitoring.
		Catalogue	Provides Catalogue Management capability for Network Services (NS) & VNF/CNF, RCA diagnostics and Slicing.
		NFV Orchestrator NFVO	Addresses NFV Orchestration which works as per ETSI NFV standards. It can also be in the form of any external NF onboarding and provisioning engine, it basically includes Resource and Network Services Orchestration. It will also handle configuration management.
		Hybrid Platform Orchestrations	Hybrid Orchestration for Network Services using VNFs and CNFs, NFV Resource Orch on private and public cloud
	Self-service Portal (SSP)	Self Service Portal	This component provides a single portal or interface to access functionalities: Release Management

			• Test Management • Platform Management • User/Subscriber Management • Site/Testbed Management • Assurance Management - Platform Assurance to view alarms, KPI's and events
		Topology	Service Topology Visualization for run-time (Visualization of VNF/CNF & NS Topology)
	Platform Readiness (PSM)	Security	The purpose of this component is the E2E security of netOps.ai Platform at all layers – NFVI, VNFs/CNFs, MANO, API Exposure.
		Audit	This component provides Platform Security Management to perform Periodic and On-Demand security scanning of all netOps.ai components as well as INFRA, Platform and VNFs/CNFs
	Asset Management & Audit (AMA)	Real time, Dynamic Inventory	This component manages the real time inventory of netOps.ai components i.e. asset (Hardware's, Software's & Services) information stored in inventory and asset inventory deployed are in sync. Will be able to do the asset reconciliation also.

		Adapters	Adaptor is defined to reconcile the differences of two incompatible protocols, each component solution will decide whether it requires any adapter service or not.
	Infra Automation Framework (IAF)	Infra Automation	The purpose of this Function is to provide a framework for IAC & TOL/TOB Automation, this framework will host the respective automation scripts of Functions in other Domains, it acts as the integration layer for Orchestration to invoke and control Automation scripts or chains of scripts
	Tenant On-boarding TOB	Adapter	Adaptor is defined to reconcile the differences of two incompatible protocols, each component solution will decide whether it requires any adapter service or not.
		Provision	This component provides Functions to provision Tenants & Services hosted on the Platform Infra Domain. e.g. On-boarding and instantiation of VNF/CNF & Network Service on netOps.ai Infra
		TOB Automation	This component helps VNF/CNF to have automated on-boarding way on infra, also some of VNF may not have VNFM which does require additional

			scripts to get on boarded on cloud infra.
		VNF Manager (VNFM)	The VNFM is responsible for the lifecycle management of VNFs under the control of the NFVO, which it achieves by instructing the VIM. VNFM operations include: Instantiation of VNF/CNFs Scaling of VNF/CNFs Updating and/or upgrading VNF/CNFs Termination of VNFs
	Platform Readiness (PRD)	Adapter	Adaptor is defined to reconcile the differences of two incompatible protocols, each component solution will decide whether it requires any adapter service or not
		Config Management.	This component manages the Infra Config, Application Level of VNF Configurations Test Management Config etc
		Capacity	This component provides functionalities like Capacity Monitoring, Threshold Management, Tenant Quota Management and Capacity Forecasting
		Patching	This component will be having ability to take new patch as input, drive them through CI/CD validation,

			make them available and safely deploy in Production as outcome
	Service & Tenant Life-Cycle Management TLM	Adapter	Adaptor is defined to reconcile the differences of two incompatible protocols, each component solution will decide whether it requires any adapter service or not
		Provision	This component provides Functions to provision Tenants & Services hosted on the netOps.ai Infra Domain along with managing its life cycle.
		Commission	Component is able to commission Tenant entities e.g. VNF/CNF and NS. It includes running applicable tests, health checks on Tenant to validate its operability before handing over to operations
		Activate	In case of hybrid environment, this component is able to request and keep track of provisioning & configuration of Network Functions in verticals external to netOps.ai for NS which cut across netOps.ai and these external verticals
		Close Loop	This component has the ability to trigger and manage explicit control loops. Also, monitor concerned conditions, manage entry conditions and policies, invoking the control

			workflows, ability to suppress the control loop etc. Close Loop is about supporting and managing the broad operational life cycle of VNFs/CNFs/Containers/VMs and ultimately NFVO components itself. Policy Engine will be OPF Sub-domain, either inside NFVO or outside but within OPS
		Assign	This component has the ability to manage the assignment of those resources to Tenant instances (VNFs, CNFs, NS's) which are not managed by NFVI itself (LB, Firewall, DHCP etc.)
		VNFM	The VNFM is responsible for the lifecycle management of VNFs under the control of the NFVO, which it achieves by instructing the VIM. VNFM operations include: Instantiation of VNFs Scaling of VNFs Updating and/or upgrading VNFs Termination of VNFs
		TLM Automation	This component helps VNF/VM to have automated way of its life cycle management on netOps.ai infra, also some of VNF may not have VNFM which required additional scripts to

			have automate life cycle management.
	Central Assurance & Analytics (CAA)	Adapter	Adaptor is defined to reconcile the differences of two incompatible protocols, each component solution will decide whether it requires any adapter service or not
		Assurance Tool	Any commercial open source assurance tools which has been used in NFVi, Container platform & VNF/CNFs for Alarm, Event and KPIs.
		Log Management	Ability of this component is to store logs generated by netOps.ai components, manage log levels i.e. Error Logs, Syslog's etc., log processing and Archiving
		Diagnostic	This component has the capability to create and manage tests in netOps.ai for performance, diagnostics and health checks etc.
		Trouble Ticket (TT)	This component is able to open automated ticket in case of any observed fault by Monitoring Component
		Monitoring	This component is able to monitor for faults and performance for proactive and predictive management It is for Pro-active and Predictive fault management. It will provide its

			input to OSS and other component within netOps.ai for various purposes. If Assurance tools are capable to have this functionality then there is no need to develop this additional function
		SLA Management (SLM)	This component is able to monitor and determine KPI's, benchmark with the defined SLA values and report in case of any violation
		Root Cause Analysis (RCA)	Behaves as a correlation engine which will be having capability to perform in-domain or cross-domain correlation of events, alarms, logs and determine the root cause in netOps.ai Platform Should mark the related events/alarms as consequential to the root cause and show impacted Tenants – Manage Propagation to the OSS System.
		Mediation	This component is optional and may be used for billing purpose if any CSP NFVi team want to report usage of NFVi to its customers in defined units.
		Reports, MIS	Manage Selected KPIs report and propagate to OSS for various purpose.

		Local Data Repo	This component behaves as a local data repository pertaining to netOps.ai components and stores meaningful events, alarms, KPI's and provided analytics services for various purpose.
		Backup & Restore Mechanism (BRM)	This component is used to provide backup and restore functionality to VNF, CNF and NFV and Container platform

Table 1: Level 3 Component details

netOps.ai Functional Use Cases

Design, CI/CD Pipeline (DCC)

- Purpose
  - ✓ To deliver productized Telco Cloud releases for netOps.ai production deployment NFVi, Container platform & CNF & Network Services Operations
  - ✓ A netOps.ai Telco Cloud Release is a super-package or distinct baseline consisting (e.g. Hardware Firmware, VMware NFV Package, VNF Vendor Package, NFVO Package etc.)
  - ✓ No release, patch or change goes to production without validation & certification
  - ✓ Enable multiple parallel pipelines for component packages
  - ✓ Validation before going to staging and production
  - ✓ DevOps agile based model environment

- Key Use Cases
  - ✓ CRUD Main Release Pipeline (Combination of software and packages used in each domain)
  - ✓ Manage new version of <any> Product Package (Combination of software and packages used in sub-domain/component)
  - ✓ Manage new set of Fixes, Patches for <any> Product Package
  - ✓ Manage new version of <any> netOps.ai developed component Package
  - ✓ DevOps Dashboard
  - ✓ netOps.ai Program Change Board control of Go/No-Go into Production (Automated OR Manual)
  - ✓ Change Freeze
  - ✓ (Non-release) Platform Build Functionality DevOps

- Artefacts & Results

- ✓ Version control of VNFs, Network Services & NFVi software package
- ✓ Validated and certified VNF/NFVi Software packages

- APIs
  - ✓ North – SSP
    - SSP
      - API Call with package name, file, checksum etc.
      - Initiate CI/CD and CTA workflow
      - Grant general access for communication

  - ✓ South- CTA, IAF, OPF, TLM & TOB
    - CTA, IAF
      - API call with set of test cases and change log (response), invoke test suite to validate templates
      - Health and Sanity Check
    - OPF
      - To evacuate the VMs from target compute hosts
      - Update VNF, CNF & NS Catalogues
      - VNF, CNF scaling in Dev and Test environment
      - VM LCM in Dev and Test environment
      - API call for service orchestration
    - TLM
      - API call with TLM for Tenant Life Cycle Management
      - VM gets migrated in production environment
      - VNF-LCM activity gets executed in production environment.
      - VNF & NS orchestrated in production environment
      - Service chain orchestrated in production environment
      - Pushes restoration snapshot or config in production environment

        - Pushes config in production VNF/CNF
        - Will handle onboarding of VNF/CNF in production environment
    - TOB
        - Onboard and Instantiate required VNF/CNF in development/test lab
        - Will be responsible for onboarding services in netOps.ai

- External dependencies
    - ✓ Inputs for NFVi templates
    - ✓ Inputs for VNFDs, CNFDs (charts) & NSDs Templates
    - ✓ Support to integrate VNF to common infra service & OSS.
    - ✓ Software package and standard template

Continuous Test Automation (CTA)

- Purpose
    - ✓ Provide a framework for automated & continuous testing and validation of all netOps.ai Platform solution components at various levels
        - Unit Testing, Integration Testing, Acceptance Testing etc.
    - ✓ netOps.ai Test Automation framework
        - Includes the common components to inject/trigger certain conditions e.g. load
        - Test-case specific automation scripts can be developed under respective domain/sub-domain, but they will reside within the Test Automation framework
    - ✓ Provide Test Governance & Control
        - Test Case Execution & Management, Regression Test control
        - Reporting, Metrics, Raising and Managing Issues, Business Objectives compliance impact

    - netOps.ai Platform mandated quality & compliance to Business Objectives assured

  - ✓ Facilitate CI/CD by integration of Pipeline Management. with Test Automation

- Key Use Cases
  - ✓ CRUD, Clone Test-case, Test-case Set definition
  - ✓ Prepare for Test-case Set
    - Data sets, data pipe-cleaning (Cleaning/Wiping the data from execution framework)
  - ✓ Execute Test-case/Set
  - ✓ Abort, Suspend, Resume Test-case
  - ✓ CRUD Result Evaluation Rule
  - ✓ Test observation recording, Logging & Auditing in relation to KPIs
  - ✓ Dashboard & Reporting
  - ✓ Test Data Management
    - Pipe-clean Test Case data, Clone Data Set
  - ✓ Manage simulator controls
- Artefacts & Results
  - ✓ Test Results
- API's
  - ✓ North – SSP, DCC, AMA, CAA
    - SSP
      - Initiate CTA workflow and test cases
    - DCC
      - API call with set of test cases and change log (response), invoke test suite to validate templates
      - Health and Sanity Check
    - AMA
      - API call to AMA for inventory update

- CAA
  - Download package from local data repo
  - Stores artifacts (Test Results), test results and version control

- South – IAF, TOB, TLM, netOps.ai Infra, Tenant
  - TOB
    - Onboard/Upgrade VNF in test lab
  - netOps.ai Infra
    - To execute the test cases
    - API call with NFVi

- External Dependencies
  - ✓ Test Lab setup
  - ✓ Defined Test Cases for netOps.ai use cases

Platform Orch & Ops - Engg Core (PEC)

- Purpose
  - ✓ Provide the essential plumbing and implementation framework components for netOps.ai Platform
  - ✓ To base underlying components which themselves do not provide business functions or UX (User Experience) Journey
    - E.g. Enterprise Service Bus, API Gateway, Event Bus, netOps.ai Health-check
    - E.g. Micro-service Orchestration
    - But they are important run-time components which need to be included in validation
  - ✓ PEC is carved out as a distinct domain because
    - Nature of dev & deployment of these components is different to other functional components

  - These components are required early in the platform build cycle
  - Off-the-shelf Applications to be used as base, only their configuration will be developed in netOps.ai

- Key Use Cases:
  - ✓ Prevents point-to-point integration with a (fairly large number of) NB of neighbors OSS, AS-IS component
  - ✓ On-demand health check of netOps.ai components
  - ✓ Monitoring of netOps.ai Blueprint components

- Artefacts & Results
  - ✓ Successful API Handling
  - ✓ Health Check report of netOps.ai components

- API's
  - ✓ North – OSS/BSS System
    - OSS/BSS System
      - API request from OSS/BSS
      - Request for a VNF/CNF service chaining for a network service
  - ✓ South – netOps.ai Sub-domains
    - Sub-domains
      - API call routing between different netOps.ai components
      - Health check for netOps.ai components

- External Dependencies
  - ✓ API's design
  - ✓ Test Setup/Lab readiness

Orchestration & Policy Framework (OPF)

- Purpose:
  - ✓ This domain provides the common frameworks and services for netOps.ai components & Automation
  - ✓ This includes following vital Functions –
    - Catalog Management, Inventory Management, Orchestration & Workflow Management, Policy Management, Service & Topology Visualization, Self-service 360° portal, Security Management, Asset Management etc.
  - ✓ This is carved out as a distinct domain because:
    - These functions offer the common Platform MANO services which are consumed by other functional domains
    - Their services are consumed across Design-time and Run-time
- Key Use Cases:
  - ✓ Catalog
    - CRUD Catalog Item (e.g. VNF Descriptor, NS Descriptor, CNF Descriptor)
    - Catalog Versioning
    - Propagate Catalog Item
    - Catalog – Component SOPs
  - ✓ Policy
    - CRUD Policy – Propagate Policy
    - Policy Engine – Component SOP
  - ✓ Real-time Inventory
    - CRUD Inventory Instance
    - Propagate Inventory Instance
    - Bulk Pub-Sub (Stream analytics and event-driven systems)
    - Inventory Repository – Component SOPs
  - ✓ Hybrid Orchestration (NS and VNFs including networks)

- CRUD Workflow Blueprint – Calculate Orchestration Graph
- In-flight changes to Imperative Workflow in execution
- Suspend, Resume Orchestration instances
- Rollback Orchestration Imperative Workflow
- Minimum Difference Calculation
- Process Policy Propagation update
- Orchestrator – Component SOPs

✓ Topology Visualization

- Visualize static topology graph of NS and VNF/CNFs
- Active topology

- Artefacts & Results
  - ✓ VNFD, CNFD (Helm Charts) & NSD
  - ✓ Successful VNF, CNF, CBF and NS Orchestration
  - ✓ Automated Service Chaining
  - ✓ Automated Policy enforcement
  - ✓ Catalogue Management for VNF, CNF and NS
  - ✓ Successful NFVO functions (NFVO, G-VNFM, Catalogue etc.)

- API's
  - ✓ North – SSP, DCC, OSS/BSS
    - SSP, DCC, OSS/BSS
      - Gets trigger from SSP and DCC
      - API request from OSS/BSS
  - ✓ South – netOps.ai Sub-domains
    - Sub-domains
      - Check the available resource before migration of VMs
      - Execute migration of VM
      - Successful migration of VMs

- Policy manager identifies action/trigger based on defined policy
- Initiate CI/CD and CTA framework
- Upload NS and VNF/CNF artifacts
- To select NSD and VNF-D, CNF-D for each stack
- Uploads required NSD and VNF-D/CNF-D (Helm charts)
- Any CNF-LCM action
- Perform required healing in VNF/CNF

- External Dependencies
  - ✓ Availability of VNFD/CNFD (charts), NSD and VNF/CNF images
  - ✓ ETSI standard NFVO
  - ✓ Non-ETSI standard orchestrator
  - ✓ ETSI standard VNFM
  - ✓ OSS/BSS integration interfaces

Self-service Portal (SSP)

- Purpose:
  - ✓ netOps.ai Self-service Portal is a 360° single UI front-end that spans all components of the netOps.ai
  - ✓ It is the only UI for all operational user roles
  - ✓ It may expose the UI of underlying component without the user realizing it
  - ✓ It provides the UX framework, and specific applications/widgets may be developed as part of the respective Function

- Key Use Cases:
  - ✓ Common Micro-services
    - Navigation Bar
    - Context-specific Help
    - Live Support & Chat bots

- UX Hints & Feedbacks

✓ Wireframe Controller

- UI (User Interface) controller

✓ Desktop Integration

- Seamless rendering of backend application GUI

✓ Real-time Dashboard framework

- Real-time rendering of streaming information

✓ Intelligent Diagnostics

- Client Bot
- Web UX Diagnostic Framework

- Artefacts & Results
  - ✓ Successful User Management
  - ✓ Successful Action Trigger Point
  - ✓ Dash boarding of netOps.ai Components
- API's
  - ✓ North – NBI API for external interfaces
    - External Interfaces
      - API calls from external interfaces to consume services of netOps.ai domains e.g. An external automated framework wants to use any netOps.ai service over HTTP call to SSP.
  - ✓ South – netOps.ai Sub-domains
    - Sub-domains
      - API calls towards southbound direction with netOps.ai Sub-domains & its Components (e.g. DCC, CTA, IAF, OPF, TLM, PSM etc.)

- External Dependencies
  - ✓ Defined User Management by CSP and Vendors

Platform Security Management (PSM)

- Purpose:
  - ✓ The purpose of this Function is the e2e security of netOps.ai Platform at all layers
    - NFVI, VNFs, CNFs, netOps.ai Components, API Exposure
  - ✓ It provides a framework for
    - Defining security policies, their distribution & enforcement. Integration with the Policy Manager Function
    - Constant Security Surveillance
    - Handling of Security Breaches
    - Closed Loop
    - Security Automation
    - Platform Lockdown
    - Reporting & Analytics
  - ✓ It also needs to integrate with wider Telco Operator Cyber Security Functions and compliance

- Key Use Cases:
  - ✓ Security Engine
    - Process Policy Propagation update
    - Security Engine – Component SOPs
  - ✓ Security Scanning
    - On-demand comprehensive scan
    - Periodic Scan
  - ✓ Manage Vulnerability
    - Handle Vulnerability
  - ✓ Manage Breach
    - Isolate Breach – Handle Breach

- ✓ Reporting & Analytics
  - Generate Report

- Artefacts & Results
  - ✓ Security Reports and audit Results

- API's
  - ✓ North – SSP
    - SSP
      - Getting trigger from SSP over NBI for on-demand security audit
  - ✓ South – netOps.ai Sub-domains
    - Sub-domains
      - API calls with different netOps.ai sub-domains (Infra, Tenant, DCC, CTA, OPF, TLM, PEC etc.) to initiate security audit on southbound interface

- External Dependencies
  - ✓ Security Management Guidelines Definitions for netOps.ai components
  - ✓ Security Management Timelines Definition

Asset Management & Audit (AMA)

- Purpose:
  - ✓ The purposes of Asset Management Function are to manage the lifecycle of netOps.ai Platform "assets"
    - Integrates with Enterprise Systems e.g. CAPEX
    - Asset Reports – Inventory, Utilization
    - May have to integrate with wider Asset Management
  - ✓ The purpose of Audit Function is to ensure that Asset inventory CMDB reflects the actual Assets and states on ground

  - This involves Periodic Asset Discovery, Discrepancy Check and Reconciliation
  - Comparing Asset current state to its golden state (e.g. configs to golden configs)

- Key Use Cases:
  - ✓ Asset Lifecycle Management
    - Manage Asset
    - Asset Manager – Component SOPs
  - ✓ License Management: delegated on-line
    - Request License
    - Return License
    - Utilization
  - ✓ License Management: within platform
    - CRUD License
    - Utilization Reports Enterprise Systems integration
    - Integration API micro-services

- Artefacts & Results
  - ✓ Inventory of netOps.ai Components
  - ✓ Asset Reports

- APIs
  - ✓ North - SSP, DCC
    - SSP
      - API call for from SSP towards AMA to get inventory view
    - DCC
      - API call for inventory update for successful hardware firmware, VMware/vCloud, VNF/CNF upgrade, upgrade new release, Network Service upgrade etc.

- ✓ South- CTA
  - For successful test cases, API call to AMA for inventory update

- External dependencies
  - ✓ Inventory object list from product vendor of netOps.ai for their product and provided solutions
    - netOps.ai will have multiple vendors in all four domains, every product does have its own inventory list which may not fulfill netOps.ai requirements for various automation purpose. E.g. A Compute hardware does not provide port information in its inventory, but this info may require in NFVi automation.

Infra Automation Framework (IAF)

- Purpose:
  - ✓ The purpose of this Function is to provide an automated solution to Infra for IAC & TOB/TLM Automations framework.
  - ✓ This framework will host the respective automation scripts of Functions in other Domains
  - ✓ It acts as the integration layer for Orchestration to invoke and control Automation scripts or chains of scripts

- Key Use Cases:
  - ✓ Automation Templates
    - CRUD Templates
    - Slice Templates
  - ✓ Automation Data Management
    - CRUD Automation Data
    - Slice Data
  - ✓ Automation Scripts

- Common Wrapper & State-model
- Invoke Script
- Freeze Script
- Kill Script
- Slice resources reserve script

✓ Automation Data Exchange

- CRUD Automation Data Exchange Rule

- Artefacts & Results
  - ✓ Automation of netOps.ai Infra

- APIs
  - ✓ North - DCC
    - DCC
      - API call for Underlay DC fabric check for port and config
  - ✓ South- netOps.ai Infra & CTA
    - Infra
      - API call over southbound interface for automated script execution
    - CTA
      - To perform health and sanity check

- External dependencies
  - ✓ Automation tools

Tenant On-boarding (TOB)

This component will be used for tenant onboarding, here Tenant is describing services where services can have multiple VNFs/CNFs/VMs.

- Purpose:
  - ✓ The purpose of On-boarding Function in netOps.ai Platform

- Take new or updated vendor VNF/CNF packages as input, validate and prepare the NFVI environment for netOps.ai to instantiate the VNF/CNFs
- Develop Network Service Blueprints, validate, prepare the NFVI & Networking environment to ultimately reach the point where Production netOps.ai Platform is ready to instantiate the Network Service

✓ The On-boarding Function therefore integrates with netOps.ai Platform Orchestrator, Catalog Manager Function, TLM, DCC and CTA components

- Key Use Cases:
  - ✓ Pre-On-boarding
    - Validated VNF Package
  - ✓ On-boarding
    - Enriched Resource Models
    - Certifying Tenant being on-boarded

    VNF

    Network Service Chain
  - ✓ Post On-boarding
    - Catalog on-boarded tenant
  - ✓ On-boarding Framework
    - On-boarding workflow template
- Artefacts & Results
  - ✓ Readymade Tenants to onboard in productions environments
  - ✓ Validated Tenants (VNFs, CNFs & NSs) in CSP catalogue
- APIs

- ✓ North - SSP & CAA
  - SSP
    - API call over north bound interface for onboard and instantiation of VNF/CNF
  - CAA
    - API call over north bound interface for any analytics data
    - For action based on defined policies

- ✓ South- netOps.ai Infra, TLM, DCC, CTA and OPF
  - Infra
    - API call over south bound interface for Infra Readiness
  - TLM
    - API call over south bound interface for successful Tenant onboarding and Instantiation, Upgrade/Update and Scale up/scale down
  - CTA
    - API call over southbound interface for health and sanity check
  - OPF
    - Provide status of VNF lifecycle over southbound interface

- External dependencies
  - ✓ VNFD, CNFD (charts) & NSD
  - ✓ VNFM from VNF vendors
  - ✓ ETSI Standard NFVO

Platform Readiness (PRD)

- Purpose:
  - ✓ Platform Readiness is set of Functions that enable netOps.ai INFRA Domain to be service ready in automated manner
  - ✓ Config Management

- ✓ Capacity Management
- ✓ Slice Management
- ✓ Infra as Code (IAC) – for Infra & Deployment Automation
  - This provides automation for NFVI deployment and configuration
  - It uses IAF as the base framework

- Key Use Cases:
  - ✓ Capacity Management
    - CRUD Trigger, Thresholds
    - Manage Capacity Threshold breach/Trigger
  - ✓ Config Management
    - Backup Config
    - Restore Config
  - ✓ Patching
    - New Patch Validation
      - Will use the DCC, CTA and IAF Frameworks
    - Deploy a Patch
    - Deploy Hotfixes
      - Will use CTA Framework and Test & Diagnostics Function
  - ✓ Slice Management
    - Map slice specific config from catalogue
    - Validate slice tasks
    - Manage Slice resources
  - ✓ IAC – Infra Day 0
    - DC & Asset Data Gathering
    - Rack/Stack Support

      E.g. Label Generation
    - Common Services Setup

      E.g. DNS, DHCP, AAA, HTTP Boot /PXE server etc.

- Compute

  E.g. IPMI 2.0 based validation
- NFV Images - Satellite Setup & Licensing Integration
- Storage
- DC Underlay Network Fabric
- DC Overlay Network
- Gateway & External Integration – WAN, Internet Platforms

✓ IAC – Infra Day 1

- 1-click config-driven Telco Cloud Setup at a DC site
- Validate Telco Cloud Base Setup
- Platform Acceleration in DC Nodes
- NFVI AAA Setup E.g. Custom Roles
- Security Configuration in DC NFVI
- Platform Readiness Tests & Commission – Infra Day 2
- Capacity Management
- Capacity Expansion
- Rolling Infra Upgrades
- Retirement & Decommissioning

- Artefacts & Results
  - ✓ Capacity of resources (NFVi, VNFs, CNFs)
  - ✓ Successful configuration of VNF/CNFs & NFVi
    - Config Management is under PRD so PRD is not only for Infra and tenant domain, can also use PRD config management for its day 3 automated application level of configurations. TOB & TLM or any NFVO cannot handle 80% of VNF/CNF application level of configuration. Lots of VNF/CNF still does required to ssh over its NBI to do application level of configurations. Here PRD config management sub-component can help to do VNF application level of configuration

        - Provision slice configuration based on the slice selection ensuring the required CNF on-boarding and resources reservations and allocation
    - ✓ Updated hardware Firmware's

- APIs
    - ✓ North - SSP & CAA
        - SSP
            - Triggering for resource or platform check over northbound interface
        - CAA
            - Triggering of actions based on alarms, KPI's and correlation parameters over northbound interface
    - ✓ South- netOps.ai Infra, Tenant, TLM, TOB & CTA
        - Infra, Tenant, TLM, TOB & CTA
            - Provide platform status over southbound interface

- External dependencies
    - ✓ VNFM, EM
    - ✓ Slice Orchestrator
    - ✓ External Controller for RAN, Core and Transport

Tenant Life-Cycle Management (TLM)

- Purpose:
    - ✓ The purpose of TLM Domain is to provide Functions to provision Tenants & Services in the netOps.ai Platform NFVI, and manage their life-cycles
        - Tenants like VNFs/CNFs, VNFCs, NS, Service Chains, etc.
    - ✓ Life-cycle Management includes automatically restoring the desired state of the Tenant (Tenant can have VNF's, NS OR combination of VNF's and

NS) or its entities (VNF/CNF, VNFC, NS etc.) based on problem Event, in a closed loop manner

- ✓ Functions use Orchestrator as a base framework and consume micro-services of Service Automation Function
- ✓ Service Automation Function uses the IAF framework

- Key Use Cases:
  - ✓ Tenant Life-cycle
    - Instantiate VNF/CNF
    - Instantiate Service Chain
    - Upgrade of VNF/CNF
    - Modify Service Chain
    - Scale-in VNF /CNF
    - Scale-out VNF/CNF
    - Isolate VNF/CNF
    - Suspend VNF/CNF
    - Resume VNF/CNF
  - ✓ Assign
    - Assign/Un-assign/Reassign resources & numbering (IP Addresses) to Tenants
    - Quota Management
  - ✓ Activate
    - Activate Network Service
    - Suspend NS Instance
    - Resume NS Instance
  - ✓ Closed-Loop Management
    - Suppress Closed-loop
    - New Closed-loop Policy
    - Update Closed-loop Policy
    - Check Closed-loop Policy interference

- Artefacts & Results

  - ✓ Updated VNFD, CNFD (charts), NSD
  - ✓ VNF/CNF & NS LCM Status

- APIs
  - ✓ North - DCC, CAA, OPF & SSP
    - DCC
      - API call over northbound interface for VNF/CNF CRUD function
    - CAA
      - API call over northbound interface for triggering actions as per events, alarms, KPI's and correlation parameters
    - OPF
      - API call over northbound interface for VNF/CNF lifecycle orchestration
    - SSP
      - Manual trigger for VNF/CNF CRUD function
  - ✓ South- TOB, CTA, netOps.ai Tenant, Infra and PRD
    - TOB, netOps.ai Tenant, Infra and PRD
      - Provide status of VNF/CNF LCM over southbound interface
    - CTA
      - Provide status of test cases execution over southbound interface

- External dependencies
  - ✓ VNFD, CNFD (charts) & NSD
  - ✓ VNFM from VNF vendors
  - ✓ ETSI Standard NFVO

Central Assurance & Analytics (CAA)

- Purpose:
  - ✓ This Domain provides Functions to monitor netOps.ai Domains and its component's, e.g. Monitoring, Alarm Handling, RCA/Correlation, Service & Business Impact, Log Management, Test & Diagnostics, Trouble Ticketing
  - ✓ It also ingests events & surveillance data, curate information, and use Analytics to provide insights & report
  - ✓ Data gathering using Agent less as well as Agent based mechanisms
  - ✓ Support for both Data Push as well as Data Pull
  - ✓ Support for at least the following protocols
    - SNMP
    - REST
    - Syslog
  - ✓ Common Data Ingestion Bus mechanism across all types of data
  - ✓ Support for both Structured and Unstructured Data
  - ✓ Support for time sequenced data with attribute/value format
  - ✓ CSM will provide secure on demand NB API for other applications like VNF-M etc
  - ✓ Auto discovery of network elements

- Key Use Cases:
  - ✓ Monitoring
    - Ingest streams
    - Alarm, Alarm enrichment
  - ✓ Closed-loop Assurance
    - Correlation & RCA
    - Process Propagated Policy

- ✓ Diagnostics
  - On-demand diagnostic test
  - Self-service diagnostic test
- ✓ Analytics

- Artefacts & Results
  - ✓ Actions based on Alarm, Event and KPIs
  - ✓ Selected KPIs
  - ✓ netOps.ai components health status
  - ✓ Analytics & Correlation Outputs
  - ✓ Backups of VNF/CNF/NFVi

- APIs
  - ✓ North - External OSS, OPF
    - External OSS
      - API call with external OSS over northbound interface to send Alarm, events and KPI to OSS.
    - OPF
      - Triggering action as per defined policy in OPF
  - ✓ South - TLM, TOB, CTA, netOps.ai Tenant, Infra and PRD
    - TLM, TOB, CTA, netOps.ai Tenant, Infra and PRD
      - API call on southbound interface to trigger action based on alarms, KPI's, events and correlation parameters

- External dependencies
  - ✓ VNF/CNF & NFVi North bound interface integration with CAA
  - ✓ VNF/CNF Element Manager capabilities
  - ✓ VNF/CNF & NFVi Monitoring tools/solutions

- ✓ External OSS/BSS Integration
- ✓ Integration with Central Data lake

netOps.ai Continuous Change Framework

The goal of the netOps.ai CCF function is to automate the entire process of CI/CD/CT (Continuous Integration, Deployment and Testing): from the time the releases/artifact updates are available in the operator's repo until the time the artifact updates are deployed, validated or rejected and delivered into operator's pre-production or production environment through multiple Lab validation and test execution.

CCF performs continuous on-boarding, provisioning and validation of new VNF/CNFs/Microservices that are released by the OEM vendors. It also does Infrastructure provisioning, application deployment and execution of test scenarios for e2e service verification.

The overall CCF solution is based on CI/CD/CT paradigm that is developed on the following building blocks:

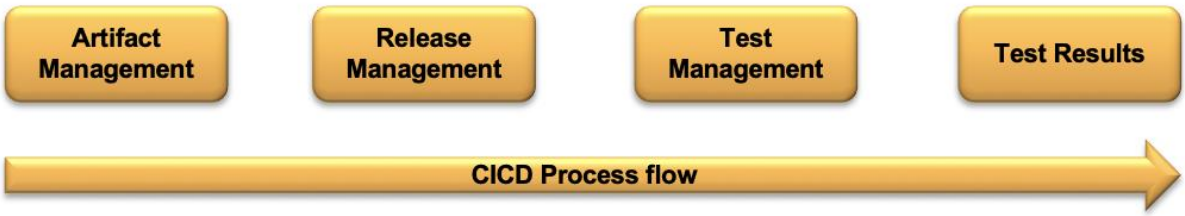


Figure 5: netOps.ai CICD process flow

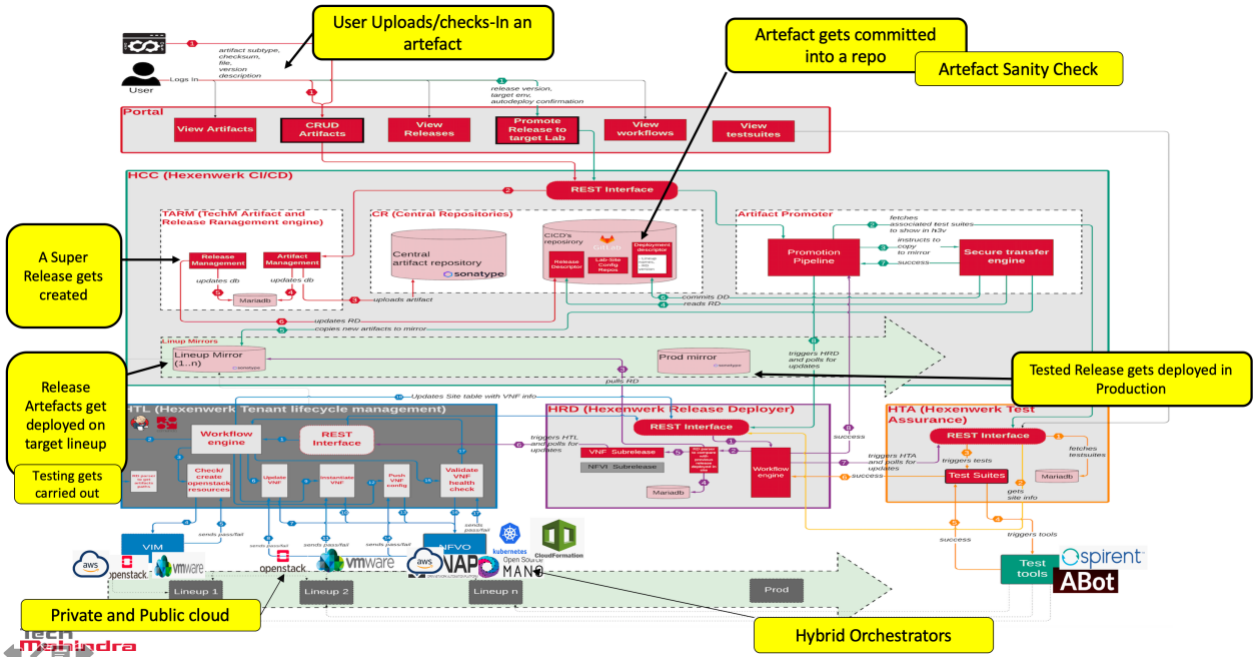


Figure 6: netOps.ai CCF Internal Architecture

Following is the CI/CD process to validate and certify the multi-vendor VNF/CNFs RAN and Core functions and Cloud platform component:

- CI/CD platform shall on-board the 5G Platform based on Containers and Kubernates
- CI/CD platform shall instantiate the Control CNFs, e.g. SMF, AMF, NSSF, NRF, PCF, etc
- CI/CD platform shall push the Day-0 configuration to the control CNFs
- CI/CD platform shall instantiate the User CNF, e.g. UPF
- CI/CD platform shall push the Day-0 configuration to UPF
- CI/CD platform shall push Day-1/Day-2 configuration to the CNFs
- CI/CD platform shall provision the CNFs on 5G Cloud Platform using the controls provided by Unity cloud (e.g. VNFM or Helm Chart)
- The CI/CD platform pulls the images and configuration artefacts from the remote OEM Vendor repository and store in the local Nexus Central repo
- The images are verified and pre-tested (sanity check) before storing locally.
- CI/CD platform maintain the Image version control using GitLab
- CI/CD platform maintain the Test Scripts version control in Cassandra

- CI/CD platform maintain the multiple Line-ups to orchestrate the CNFs on 5G Cloud Platform
- CI/CD platform shall perform the 5G Cloud platform patch upgrade
- CI/CD platform supports CNFs software patch upgrade
- Automate the non-functional, functional and performance scenarios covering agreed Test cases
- CI/CD platform also enable users to create Test Suites for different Lab line-ups.

Below is the detailed workflow of the major CCF processes.

Artefact Management

- Integrated with Vendor repositories (Can be hosted on AWS S3, or remote OEM vendor Repo)
- Scheduled polling for new updates
- Convert to Machine based Image and instantiate on a Vagrant box (optional)
- Perform CRC check for the integrity of the images
- Upload Artefacts to NEXUS repositories

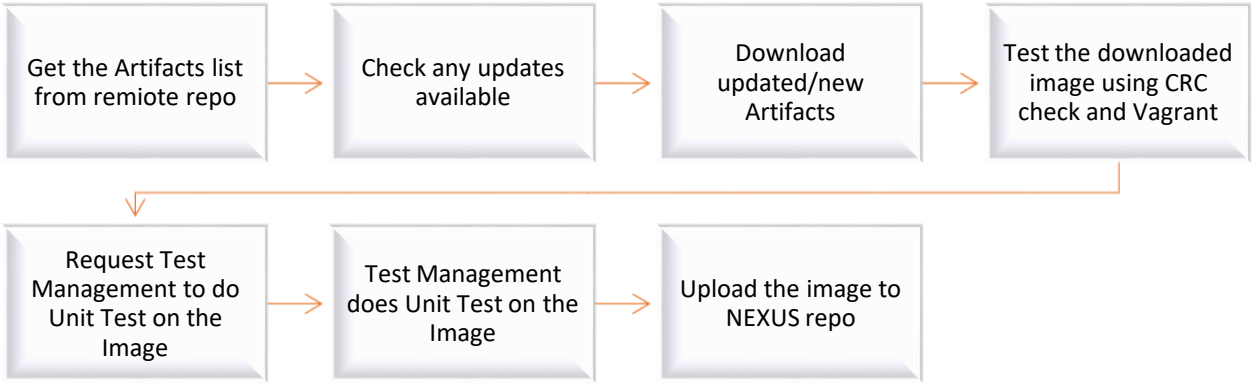
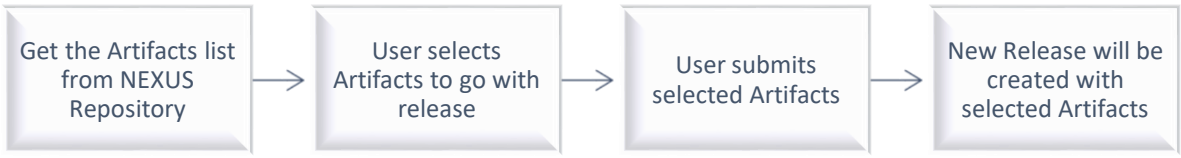


Figure 7: netOps.ai Artefact Management Flow

Release Management

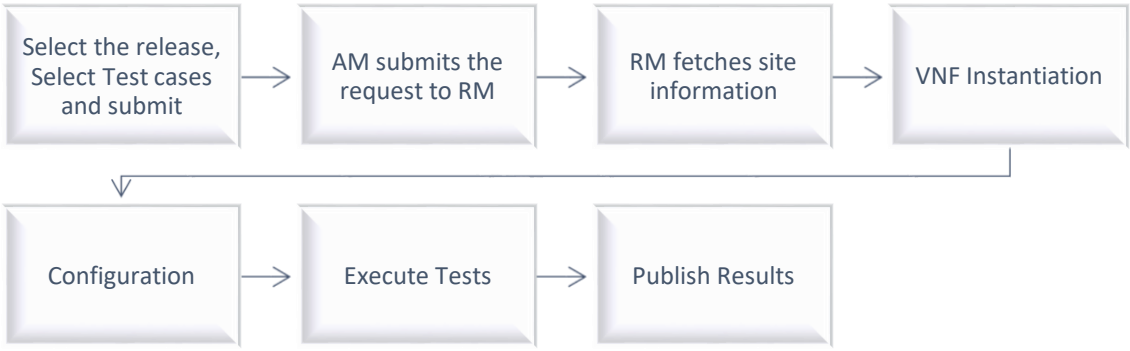
- ✓ Create/Manage Releases as per CSP Change Management Business workflow process
- ✓ Release composition with Artifacts from multi-CNF/VNFs
- ✓ Release Dashboard GUI

- ✓ Dynamic Release template creation
- ✓ Maintain Release Descriptors
- ✓ Maintain Release Unit cloud platform upgrade patches, if any.



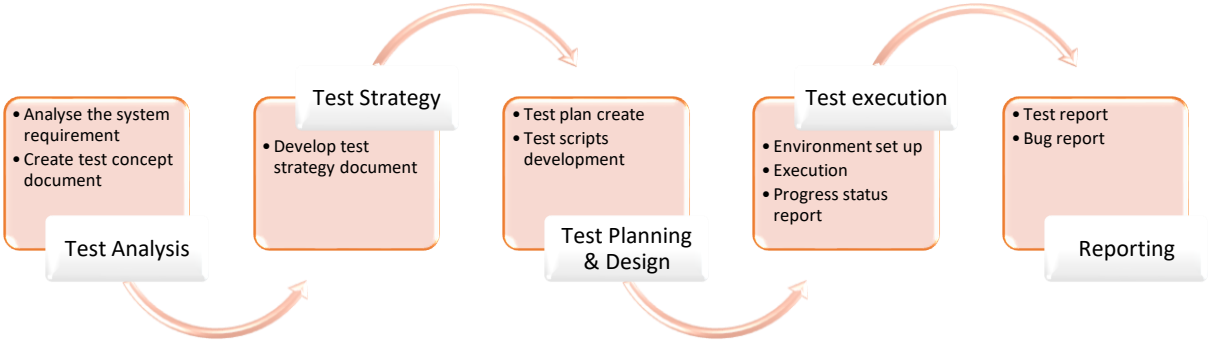
Test Management

- ✓ Dynamic Test Suites Selection
- ✓ Dynamic selection of multiple Test Lab line-ups (if available)
- ✓ Deploy Selected Release on Multiple Lineups (if available)
- ✓ CNF/VNF deploy, Instantiation and Configuration
- ✓ Config the Test tools (3rd party test tools or simply scripts)
- ✓ Execute Test Suites in each Lab lineups per pipeline basis
- ✓ Release Test Results
- ✓ Move to next testbed/Lab lineup



CICD Lab Testing Process

Following diagram depicts the process followed for the VNF/CNF CICD Pipeline testing. This process is followed for each test line up and for the new test requirement.



Test Analysis

Description	The purpose of test analysis is to understand the type of testing need to be executed for the released CNF / Microservices. Based on the business requirements an effort estimation and a testing commitment is given for a final approval.
Inputs	Microservices / CNF Release plan, Technical solution / feature details, Planned customer details
Outputs	Analysis and High-level Test Concept Effort Estimation
Reporting	Lab PMO
Tools	Excel, MSWord
Predecessor	n/a as analysis is the first process in the chain
Successor	Test Concept

Test Strategy

Description	The purpose of test concept is to deliver a test strategy for the acceptance phase, including the usage of tools and test environment

Inputs	Implementation Plan, Technical solution, Test Analyse
Outputs	Detailed Test Concept and test strategy document Effort Estimation
Reporting	Lab PMO
Timeline	Service Request can be delivered anytime for analysis. The SR size defines the duration of the analysis phase
Tools	Word and Excel
Predecessor	Test Analysis
Successor	Test Planning and Design

Test Planning and design

Description	The purpose of the Test Planning and Design Phase is to create the Test plan and the necessary scripts for the test execution
Inputs	Test Concept, Implementation Plan, Technical solution
Outputs	Test Design, Acceptance Test Plan, Test Scripts
Reporting	TMS
Timeline	As agreed in the project plan
Tools	TMS, MSWord
Predecessor	Test Concept
Successor	Test Preparation

Test Preparation

Description	The purpose of test preparation is the installation of the complete Test environment for the realisation of the tests. It includes the CNF / Microservices on boarding, Configuration of all CNF / Microservices, tools and interfaces
Inputs	Design, Test Concept and ATP
Outputs	Update Test Documentation
Reporting	TMS
Timeline	As agreed in project Plan
Tools	TMS
Predecessor	Test Planning
Successor	Test Execution

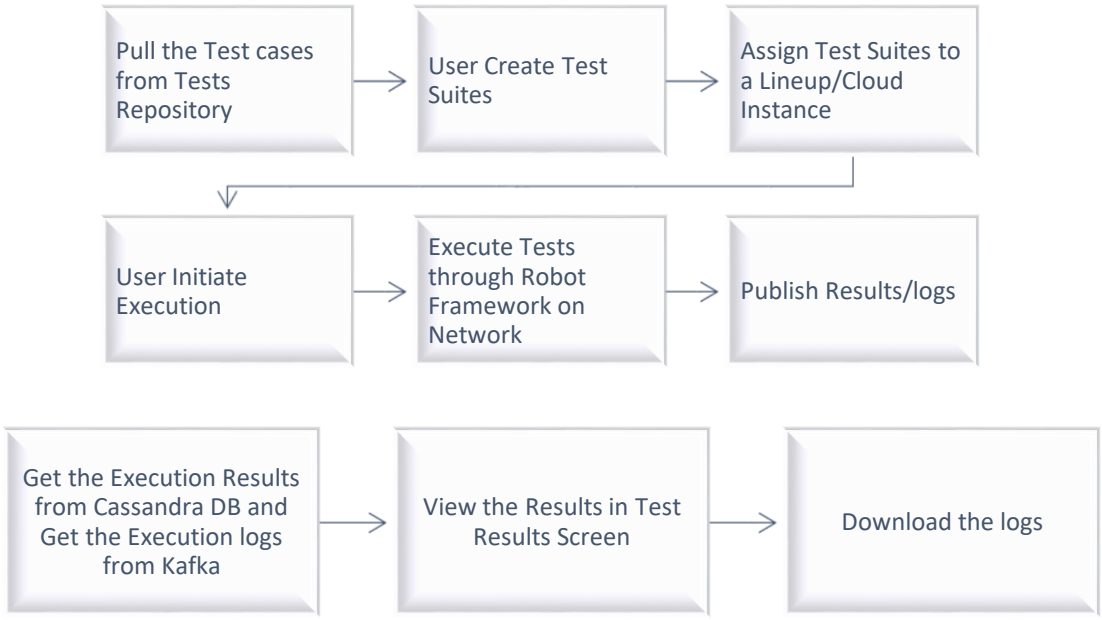
Test Execution & Reporting

Description	This is the main part of the CNF / Microservices Certification Test process. The purpose of test Execution of the test cases as specified in the Test Plan as well as the trouble shooting of failures.
Inputs	Design, Test Concept and Test Plan
Outputs	Results of Test cases
Reporting	TMS
Timeline	As agreed in project Plan
Tools	TMS
Predecessor	Test Preparation
Successor	Release to Customer

Test Management

- ✓ Test Cases Repository

- ✓ Test Suites Creation/Management
- ✓ Add/Manage Test Suites to Sites/Cloud Instances
- ✓ Execute Test Suites
- ✓ Live Test Results
- ✓ Test Results History
- ✓ Download Execution logs/ Results



netOps.ai Toolset

Domain	Sub-Domain	netOps.ai Tools	High Level Description	Tool Type (Licensed/ Opensource)
netOps.ai BUILD	Design, CI/CD Pipeline (DCC)	Git Repository	Repository for Distributed Version Control	Open Source/ Commercial
		GitLab Runner Engine	GitLab Runner Engine is the open source product which can be used to run multiple jobs concurrently and send the results back to Git Repo	Open Source/ Commercial
		Python Micro-services	Building Microservices application using Python	Open Source
		REACT	Framework used for developing Single Page applications	Open Source
		SonaType Nexus	Repository manager, creating a single place for teams to manage all their digital artefacts efficiently	Open Source
		ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process	Open Source

			modelling and notations) concepts	
		Maria DB	Database Server	Open Source
		Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Continuous Test Automation (CTA)	Robot Framework	Test Automation Framework consists of a set of tools, techniques and abstract rules. Helps in writing automated test cases and simplifying test automation process.	Open Source
		Python	Language which helps in creating automated test scripts	Open Source
		Ansible	Scripting Language used for creating automated test scripts	Open Source
		Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		Maria DB	Database Server	Open Source

		Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
		GitLab	It will be used to manage Git repositories.	Open Source

Domain	Sub-Domain	TechM Suggested Tools	High Level Description	Tool Type (Licensed/Open Source)
netOps.ai Orchestration & Automation	Platform Orchestrator & Operation - Engineering Core (PEC)	Netflix Zuul	API GW	Open Source
		Kafka & ZooKeeper	Event Bus	Open Source
		Kubernetes	Microservice Orchestrator	Open Source
		Django	Micro Services Framework	Open Source
		Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		5. Maria DB	Database Server	Open Source

		6. Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Orchestration & Policy Framework (OPF)	1. Apache ARIA (Optional- In case ETSI NFVO Available)	TOSCA Orchestration engine	Open Source
		2. Mistral	Mistral is the OpenStack workflow service. This project aims to provide a mechanism to define tasks and workflows without writing code, manage and execute them in the cloud environment.	Open Source
		3. ConfD Basic	Management agent software framework	Open Source
		4. Ansible	Scripting Language used for creating automated	Open Source

			Orchestration scripts	
		5. Python	Language which helps in creating automated Orchestration scripts	Open Source
		6. YANG	Configuration Modelling Language	Open Source
		7. GitLab	It will be used to manage Git repositories.	Open Source
		8. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		9. Maria DB	Database Server	Open Source
		10. Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Self-service Portal (SSP)	1. Angular JS	Framework used for developing Single Page applications	Open Source

		2. Python Micro-services	Building Microservices application using Python	Open Source
		3. MariaDB	Database Server	Open Source
		4. Cassandra	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
		5. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source/ Commercial
	Platform Security Management (PSM)	1. OPENSCAP	Administration and Audit tool	Open Source
		2. Ansible	Scripting Language used for creating automated scripts	Open Source
		3. Python	Language which helps in creating automated Orchestration scripts	Open Source
		4. Python ViewFlow	Viewflow is used for workflow management and is	Open Source

			based on BPMN (Business process modelling and notations) concepts	
		5. Maria DB	Database Server	Open Source
	Asset Management & Audit (AMA)	1. Netbox	Web Application for Inventory and Asset Management	Open Source
		2. Ansible	Scripting Language used for creating automated scripts	Open Source
		3. Python	Language which helps in creating automated Orchestration scripts	Open Source
		4. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		5. CMDB	Asset Management Tool	Open Source
	Infra Automation Framework (IAF)	1. NetBox	Web Application for Inventory and Asset Management	Open Source
		2. Bifrost Ironic	Ansible Playbook which will automate the task	Open Source

			of deploying a base image onto a set of known hardware using ironic	
		3. MariaDB	Database Server	Open Source
		4. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		6. Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Tenant On-boarding TOB	1. Python Django Microservice	Building Microservices application using Python	Open Source
		2. Ansible	Scripting Language used for creating automated scripts	Open Source
		3. Python	Language which helps in creating automated Orchestration scripts	Open Source

		4. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		5. Maria DB	Database Server	Open Source
		6. Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Platform Readiness (PRD)	1. Python Micro-service	Building Microservices application using Python	Open Source
		2. Angular JS	Framework used for developing Single Page applications	Open Source
		3. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source

		4. Maria DB	Database Server	Open Source
		5. Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
	Service & Tenant Life-Cycle Management TLM	1. Python Django Microservice	Building Microservices application using Python	Open Source
		2. Angular JS	Framework used for developing Single Page applications	Open Source
		3. ONAP CLAMP	Platform for designing close loops	Open Source
		4. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		5. Maria DB	Database Server	Open Source
		6. Cassandra DB	Database Servers which maintains data among many	Open Source

			commodity servers to avoid any single point of failure	
	Central Assurance & Analytics (CAA)	1. Zabbix	Monitoring Software Tool	Open Source
		2. Apache Flink	Stream Processing Framework	Open Source
		3. Apache NiFi	Automatic Flow Software	Open Source
		4. Elastic Search	Search Engine with an HTTP interface and JSON documents	Open Source
		5.Logstash	Data processing pipeline for injecting data from various sources. Once injected, it gets transformed and sent to the desired repo	Open Source
		6. Kibana	Visualization Plugin for Elasticsearch	Open Source
		7. Python ViewFlow	Viewflow is used for workflow management and is based on BPMN (Business process modelling and notations) concepts	Open Source
		8. Maria DB	Database Server	Open Source

		9.Cassandra DB	Database Servers which maintains data among many commodity servers to avoid any single point of failure	Open Source
		10. DROOLS	Business rule management system with a forward and backward chaining inference based certain rules	Open Source
		11. Hadoop	Data Analytics system	Open Source/ Commercial
		12. FluentD	Big Data tool, analyses event logs, application logs etc.	Open Source

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