NANC

NetOps.ai & AWS powered Network Cloud

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1 Executive Summary

Today's Network Operators are facing a dilemma that in spite of having spent a lot of time, effort and resources in virtualizing their infrastructure, the business benefits have rarely been achieved. The prime reason being that although the networks and platforms have evolved, the tools, systems, and operational processes around them have not changed much. Also, the level of robustness and cost effectiveness that is provided by the public cloud platforms is not easily replicable in private cloud setups based upon vmware or openstack.

To address this problem, and to ease the cloud migration journey of Operators for 5G, TechM and AWS have developed a cutting-edge Telco Cloud solution called NANC. It is a strategic partnership between AWS and Tech Mahindra to develop World's First End to End Public Cloud Telco Platform for an Operator's 5G/Networks of the Future Needs.

The solution utilizes AWS' market leading offerings like Public Cloud, Virtual Private Cloud and AWS Outpost along with Tech Mahindra's E2E orchestration and automation framework netOps.ai to provide a seamless and highly modular Telco Cloud Offering that promises to revolutionize the way current Telco Clouds are designed, developed, deployed and managed.

This document provides an overview of NANC, and also details out the problems faced by today's Operators, along with a high-level approach of cloud migration. A sample TCO calculation is also provided to elaborate the cost benefits of a public / hybrid cloud, apart from the robustness, QoS, and ease of Operations inherent in Cloud operations.

2 CTIO Dilemma

The landscape for Network Transformation has evolved. Previously, an operator's decision was simply between whether to implement NFV or not. However, the current dilemma is slightly more complex. Nowadays, the defining question is something along the lines of: "Whilst I have virtualized my network, I am still yet to realize the three key business objectives of 'reduced cost', 'greater velocity', and 'quality'".

TechM's 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 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 [1]all three objectives at the same time. Some of the primary factors attributing to this failure to achieve business objectives are:

- **No True Best-Of-Breed NFVI Implementations:** Most of the OpenStack based implementations have been packaged vertically with VNFs. This has caused the operators to continue to run their networks in the same way as before and therefore not achieving the true benefits of Virtualization like disaggregation and vendor independence

- **Non-Cloud Native VNFs**: Almost all of the present day VNFs are not cloud-native[2]. This means that any fault on hardware or infra layer has a direct negative effect on the VNF and on the service it provides. Since the COTS servers are inherently expected to be unreliable, they cause degradation in overall service quality towards end customer

- **Inefficient Infra Capacity Utilization:** Today's VNFs are generally run with more than the required CPU, Memory and Storage. This can be attributed to inefficient design practices like CPU pinning and SR IOV etc., in addition to the legacy practice of planning capacity

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[1] Independent TechM Survey

[2] Cloud-native: is an approach to building and running applications in which apps are architected specifically to run in the elastic and distributed nature required by modern cloud computing platforms. Apps are loosely coupled, meaning the code is not hard-wired to any of the infrastructure components, so that apps can scale up and down on demand and embrace the concepts of immutable infrastructure

for peak traffic figures. This inefficiency translates to the operator being forced to buy lots of extra COTS hardware upfront, which makes the business case non-viable

- **Poor Orchestration & Automation:** Most of the transformed networks continue to be run with legacy assurance and fulfilment tools. New methods of orchestration and automation that included getting away from OSS, have generally not been successful.

- **Staff Upskilling:** It has been a struggle for the CSPs Network Engineers to come to grips with IT centric technologies and methodologies such as DevOps and CI/CD. Likewise, the IT engineers have been unable to comprehend the complexities involved in setting up a service critical network

- **Operating Model:** Many networks have continued to work with distributed and dis-jointed operations; NFVI operated by IT and the network/services operated and managed by the network operations. This dis-jointed way of managing the network has introduced extra complexity and the ability to troubleshoot and fix issues fast has been impacted.

- **Continued Focus on Infrastructure:** Operators continue to spend a lot of effort and resources on running and managing virtualization infrastructure due to lot of manual and error prone methods and technology. This is taking their focus away from developing, deploying and managing new services faster, cheaper and better. An introspective question needs to be asked: "Is Data Center our primary line of business?"

3   Networks of Future (NoF) Design Tenets

With the advent of 5G many of these issues could get resolved, as the 5G CNFs are expected to have been developed with microservices and stateless containers in mind. But, just implementing the new generation of network functions is not enough to meet the demands and business objectives of the dreamt about nirvana of "Web-Scale" Operations for network Operators.
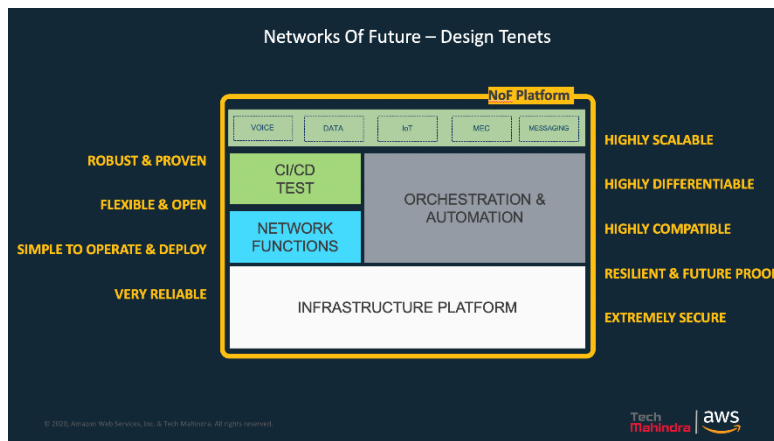

Figure 3-1 Telco Network Of Future Design Tenets

Networks of the Future design tenets such as robustness, simplicity, reliability, scalability, differentiability, compatibility and resiliency of the infrastructure platform along with orchestration/automation solution will play a major role in achieving the same.

What is required is a new breed of infrastructure platform and automation/orchestration solution that makes the relevance of HW and Infra much less than what it is presently, a solution that has already achieved most, if not all, design tenets and instills confidence in the overall network transformation.

4 NANC (NetOps.ai and AWS powered Network Cloud)

NANC is the result of a strategic partnership between Amazon Web Services (AWS) and Tech Mahindra (TM) to develop World's First End to End Cloud Platform for an Operator's 5G/NoF Needs.

The solution utilizes AWS' market leading offerings like Public Cloud, Virtual Network Cloud and AWS Outpost along with Tech Mahindra's E2E orchestration and automation framework netOps.ai to provide a seamless and highly modular Telco Cloud Offering that promises to revolutionize the way current Telco Clouds are designed, developed, deployed and managed!
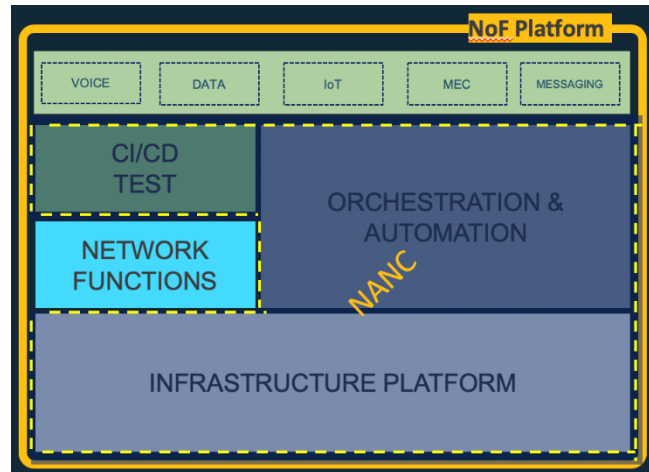

Figure 4-1 Unique E2E Telco Cloud Solution

NANC has been designed to suit all types of Operators ranging from Greenfield MNO to Brownfield MNOs who have both PNFs and VNFs already deployed in production and are now looking for a unified cloud platform strategy for both their Network and IT workloads.

4.1 NANC: Key Solution Highlights

- Primarily designed and developed for RAPID and SPEEDY deployment of 5G Networks

- NANC has been designed to suit all types of Operators ranging from Greenfield to Brownfield MNOs.

  - An Operator who has both PNFs and VNFs already deployed in production and is now looking for a unified cloud platform strategy for both their Network and IT workloads and not wanting to go through another set of "trials"!

  - An Operator who is yet to realize their business objectives due to high CAPEX and OPEX costs along with slow speed of change

  - An Operator looking to leapfrog complexities of "seemingly next steps" of k8s on bare-metal!

- One Stop Shop for all NFV/Container Platform/Infra, Orchestration, Automation, Assurance, CI/CD and all operational needs

- Fully managed hosted end to end solution. Zero CAPEX, Low OPEX model

- Core Network Control Plane Functions (CPF) hosted in one or more AWS Regions for HA/DR with secure data in transit over AWS network using advanced networking constructs like AWS Direct Connect, AWS VPN and Elastic Load Balancing.

- 5G vRAN CU/DU, Core Network User Plane Functions (UPF) and Mobile Edge Compute (MEC) hosted on AWS Outposts

- Tech Mahindra netOps.ai Orchestration & Automation hosted in one or more AWS Regions for HA/DR with secure data in transit over AWS network

- Single Pane of Glass View for all fulfilment and assurance needs of an operator; managed through a model driven REACT based netOps.ai UI

- Managed VNF/CNF Onboarding, Certification and benchmarking Service. The service includes working with various 5G eco system partner vendors like Nokia, Ericsson, Cisco, Affirmed, Mavenir, Altiostar, Samsung etc. to ensure full compatibility and performance benchmarking of their respective VNFs/CNFs.

- Fully Integrated Analytics & Assurance stack for AWS, VNFs, CNFs, Orchestration & Automation:

   o Hosted on the Cloud as a service

   o Common Metrics, Logs and Events Ingestion mechanisms

   o Policy based Fault Management and Alerting using AWS CloudWatch and other Enterprise Open Source solutions like Prometheus

   o Unified Data Lake for Network Data using AWS Lake Formation

   o Network Big Data Analytics and AI/ML RCA using AWS EMR

   o netOps.ai Self Service Portal for Fault, Alarm and Performance Management

- Handy Cloud TCO measurement and monitoring tools to access, organize, understand, control, and optimize the network platform operations and usage cost

- A Lightweight yet powerful End to End Service Orchestrator & Automation Engine packaged using AWS Cloud Formation along with Opensource empowered NetOps.ai

4.2   NANC: Base Reference Architecture

NANC Infrastructure components are fully addressed by AWS Virtual Private Cloud and AWS Outposts. The Orchestration, Automation and Continuous Integration, Deployment and test are addressed by a combination of netOps.ai solution components and AWS native services.
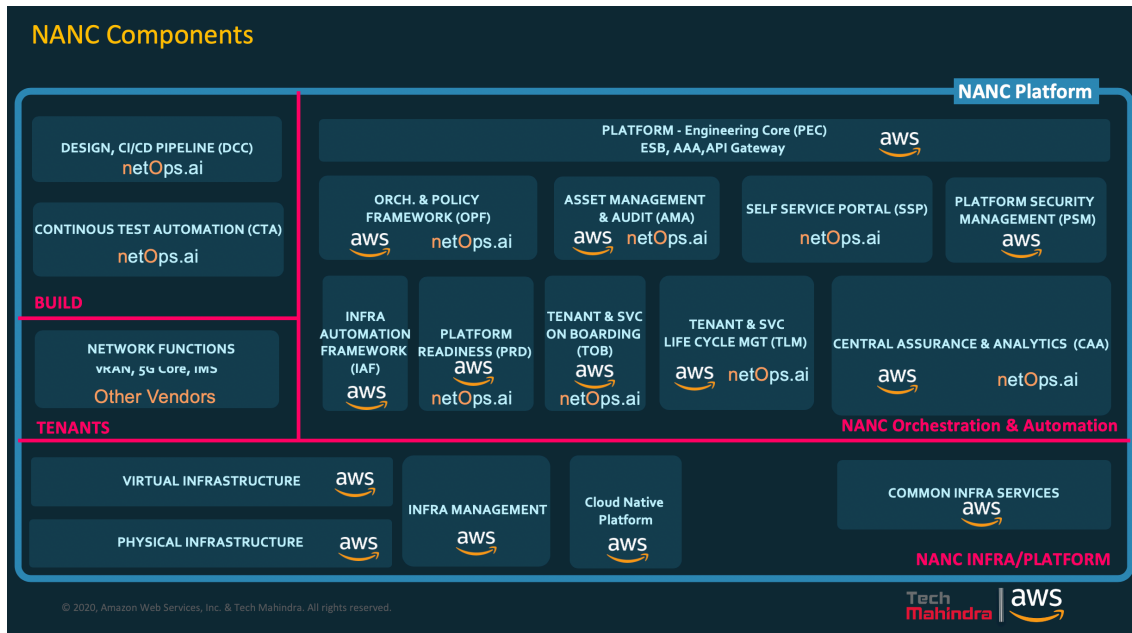
Figure 4-1 NANC Logical Architecture

In its very basic implementation of NANC, the operator has the choice to deploy vRAN and MEC on AWS Outposts or other workloads like 5G Core UPF that require low latency access to on-premises systems. Any other network functions requiring local data processing, local data storage or high throughput/internet off-load

AWS Outposts is a fully managed service that extends AWS infrastructure, AWS services, APIs, and NANC netOps.ai framework to on-premise datacenter, co-location space, or on-premises facility for a truly consistent hybrid experience.
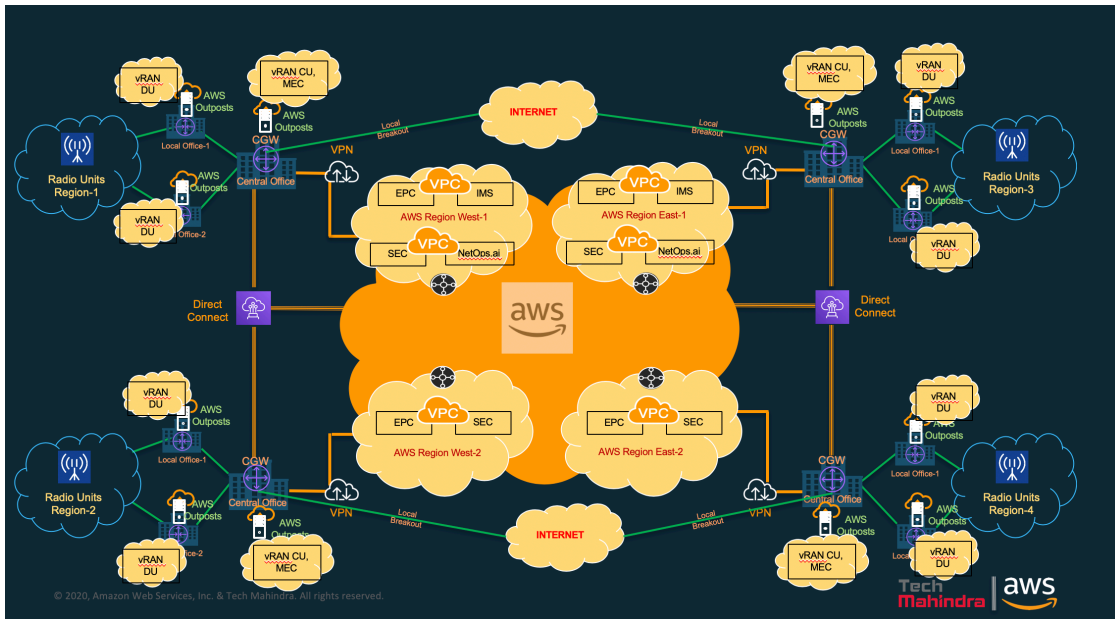
Figure 4-2 NANC Base Reference Architecture for 5G Core

NANC utilizes AWS Virtual Private Cloud solution for the purpose of hosting centralized functions like 5G Core CPF, SMF, IMS etc. Amazon Virtual Private Cloud (Amazon VPC) allows provisioning of a logically isolated section of the AWS Cloud where AWS resources are launched in a virtual network that is defined by the Operator. There is complete control over the virtual networking environment, including selection of own IP address range, creation of subnets, and configuration of route tables and network gateways.

E2E Orchestration and automation is achieved through a mix of netOps.ai and AWS management tools like AWS Cloud Formation.

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.
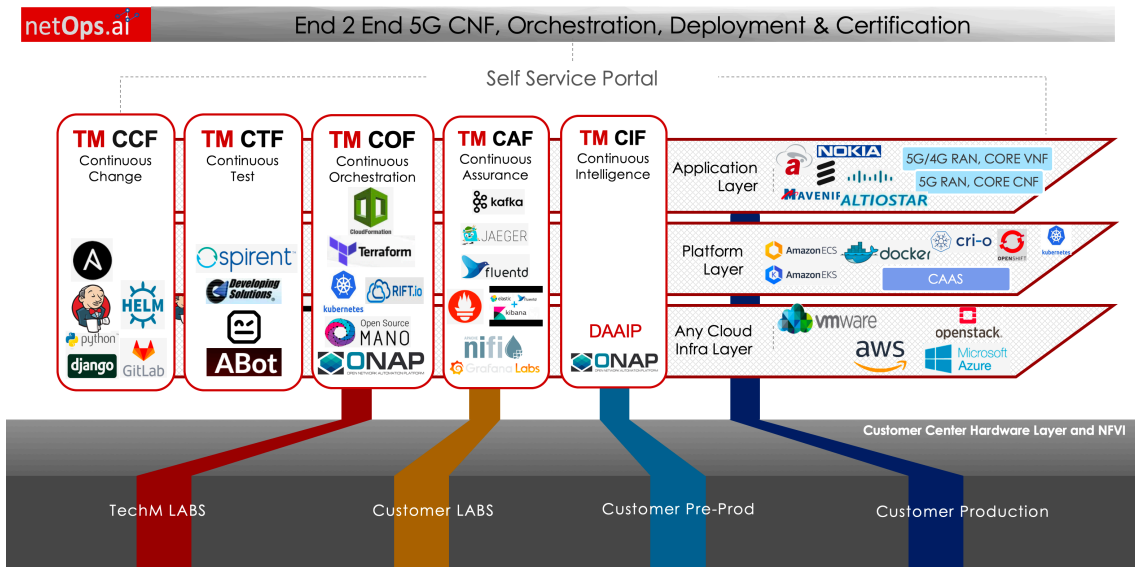
Figure 4: Five Functions of **netOps.ai**

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**
  - o Upload Artefacts (images, vnfd, Helm Charts)
  - o Auto Release Management
  - o Auto Validation of Parallel Releases on multiple test beds and lab-line-ups
  - o Integrated with E2E Slice Lifecycle Management

- **Continuous Orchestration**
  - o Automated deployment of images on Cloud and Container Platforms
  - o Auto Provisioning and Execution of VNF/CNF Life cycle management
  - o Integrated with E2E Slice Orchestration

- **Continuous Testing**
  - o Integrated with Continuous Change
  - o Automated test execution and Reporting
  - o 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

4.3   NANC : Key Advantages

Lowest TCO: TCO of private cloud depends on the amount of the HW customer is procuring for compute, storage cost, power, space, lease, rack & stack, truck roll for maintenance, networking cost, human cost, Operations cost and life cycle management cost etc. AWS Public Cloud / AWS Outposts takes most of those headaches away in a cost efficient manner by allowing the operator to extend AWS cloud into its data center and at the same time leverage AWS cloud global infrastructure and same tools, APIs, SDKs, management and services that is used by the customers to manage their AWS public cloud infrastructure. TCO of a public Cloud like AWS, on the other hand, is up to 65% lower compared to Private Cloud.

Single Pane of Glass View: For all fulfilment and assurance needs of an operator. NANC's Self Service Portal (SSP) Component aggregates all business functions like Infrastructure as a Service, Deployment, capacity management, infrastructure monitoring, VNF/CNF monitoring, performance monitoring, Life Cycle Management etc.

No Need for Expensive Hardware Re-fresh: A private cloud setup means spending hundreds of thousands of dollars on new hardware and software upfront. This may be okay from CAPEX perspective, but getting the organization to spend similar amount every year is a big challenge

Hugely Better Utilization Rates compared to Private Cloud: For a private cloud an organization has to build and maintain all kinds of servers and switches to meet spikes in demand across various domain/tenants. AWS offers the same spare demand on a pay-as-you-need-it basis.

Data Center Business: Setting up a private cloud probably gets an operator deeper into the Data Center Business compared to the traditional on-premises servers.

NANC is much more SECURE than a private cloud; Several factors contribute to this:

- **Hardened and proven:** Contrary to general belief, AWS is many times more secure than a private cloud. AWS has hardened through continual hacking attempts; hundreds of hackers have been pounding AWS and Amazon for years now. The public cloud providers now have the ability to handle anything at this point.

- **Expertise:** In addition, AWS attracts and retains the best security people available by seeking out top security experts paying them well and treating them as the primary part of their businesses, which they are. It is difficult to achieve similar levels of staffing expertise in an Operator

- **Perimeter Complacency**: Private clouds give a false confidence that "If it's on the internal network, it must be secure!"

- **Security:** Data Security is not the main line of business for Operators. An Operator may have a lot of talented and knowledgeable people, but is data security the main line of business for a CSP?

- **Penetration testing:** Even if an Operator does network penetration testing on a regular basis (which many organizations don't), it is still a very transient activity (report at a given point of time)

Staff Competence & Training: There is a huge amount of training material and resources available around AWS and associated management/orchestration and operations. This helps Operators in getting their staff trained and build competence in Cloud based infrastructure and operations.

5 Customer Engagement Model:

NANC is offered as a closely integrated working model with AWS, each working as an equal partner to serve our customers as One single team. TechM acknowledges the world class platform maturity of AWS and complements it with TechM's decades of deep expertise in providing Professional services and System Integration capabilities to our customers. In addition, TechM has developed a hybrid E2E Orchestration & automation framework netOps.ai to provide the end to end orchestration and Assurance capabilities for implementing and operating the networks of the future in areas like Slicing and CI/CD.

Aligned to the unique and evolving needs and preferences of our customers, we provide multiple engagement options as below:

- TechM as **PRIME** contractual party with Customer and includes AWS platform and attached applications and services on a pay-as-you-use subscription-based model, as part of TechM's overall offering.

- Customer can have a separate direct contract with AWS for platform subscription; and TechM provides the implementation, system integration, operations, VNF migration, testing, certification, and other professional services via a separate Services contract. TechM also provides its netOps.ai framework on a subscription licensing basis.

6 TCO Benefits of NANC

TechM has done some initial analysis of cost benefits of using a public cloud infrastructure versus an on-prem Virtual infrastructure and seen major cost benefits in using public cloud model. A sample scenario below shows that using AWS cloud services instead of an on-prem Data Center results in substantial (up-to 70%) TCO savings over a period of 3 years

On-Premises vs. AWS Summary

You could save **71%** a year by moving your infrastructure to AWS.

Your three year total savings would be $ 4,094,008.

3 Years Cost Breakdown

3 Yr. Total Cost of Ownership		
	On-Premises	**AWS**
Server	$ 5,130,669	$ 1,438,861
Storage	$ 227,486	$ 105,173
Network	$ 403,385	$ 36,957
IT-Labor	$ 24,300	$ 110,841
Total	$ 5,785,840	$ 1,691,832

AWS cost includes business level support

	Hardware – Server, Rack Infrastructure, PDUs, ToR Switches (+Maintenance)	Software - OS, Virtualization Licenses (+Maintenance)	Overhead		
1 Server Costs			Space	Power	Cooling
2 Storage Costs	Hardware – Storage Disks, HBAs, SAN/FC Switches	Storage Admin	Overhead		
			Space	Power	Cooling
3 Network Costs	Network Hardware – Core/Aggregation Switches Bandwidth	Network Admin	Overhead		
			Space	Power	Cooling
4 IT Labor Costs	Server Admin Virtualization Admin				

Figure 6-1 Major Cost Categories considered

Your On-Premises Cost Breakdown
Storage

- Raw Capacity : $ 99,123 [44%]
- Backup : $ 18,400 [8%]
- Overhead : $ 107,771 [47%]
- Admin : $ 2,192 [1%]

Server

- Hardware : $ 2,368,170 [46%]
- Software : $ 1,697,259 [33%]
- Overhead : $ 1,065,240 [21%]

Network

- Bandwidth : $ 60,000 [7%]
- Gear : $ 343,385 [43%]
- Admin : $ 403,385 [50%]

Your AWS Cost Breakdown
Storage

- EBS : $ 29,361 [29%]
- S3 : $ 1,377 [1%]
- S3IA : $ 1,110 [2%]
- EFS : $ 67,682 [68%]

Compute EC2

- 3 Yr EC2 Instance Savings Plan : $ 1,426,479 [100%]
- On Demand : $ 0 [0%]

EBS

- IOPS : $ 0 [0%]
- EBS Volumes : $ 26,542 [98%]
- Snapshot : $ 560 [2%]

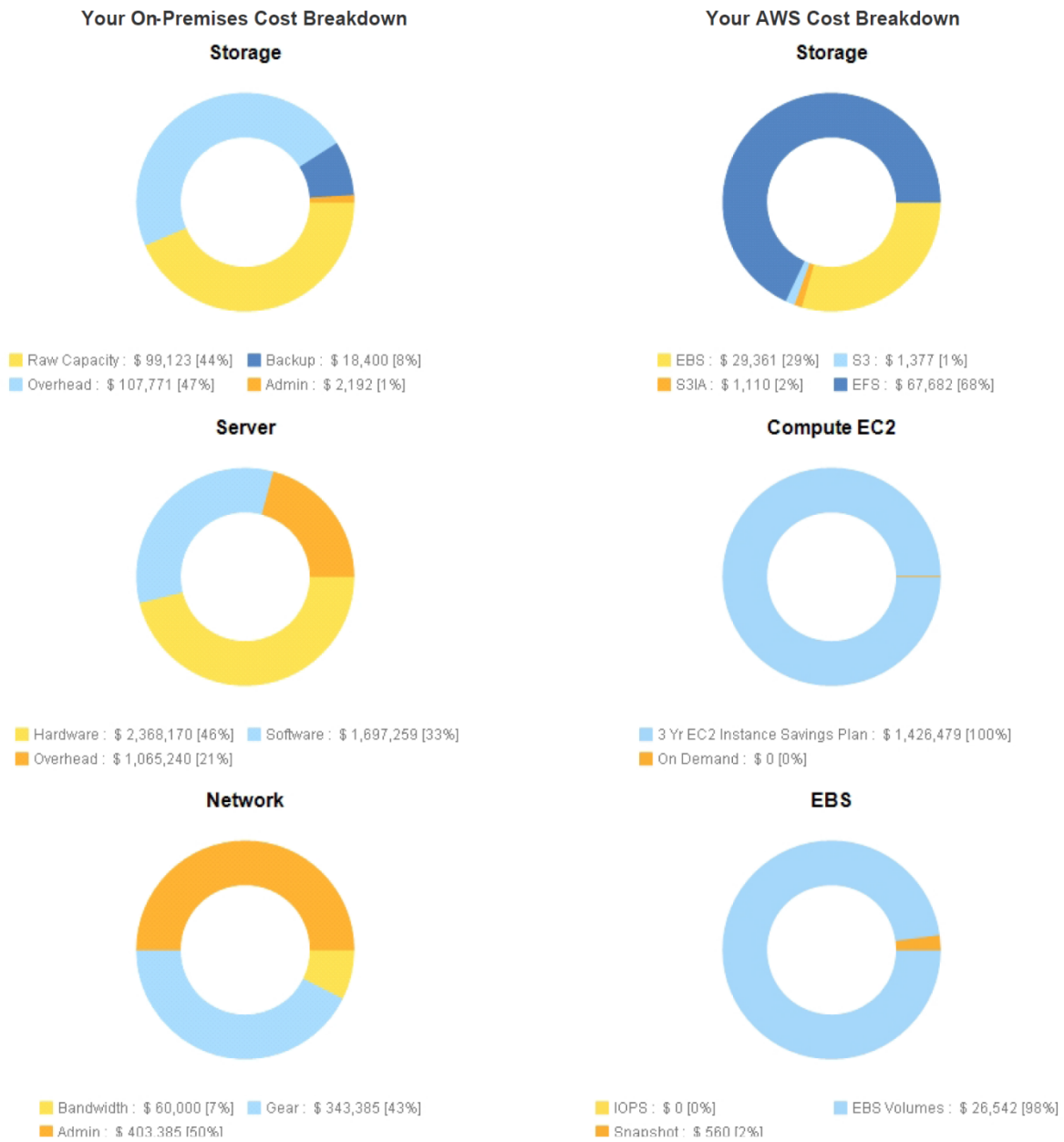*Figure 6-2 Cost Breakdown*

We have considered Acquisition and Operational costs in TCO calculation, for the cost components shown in Fig 5-1.

It is worth noting that there are **many other costs in managing an on-premise Data Center which have not been considered in this model**. E.g. – OSS tools and systems and related manpower cost, software costs for databases, systems management, middle tier software costs. Additional operational costs can include costs associated with facilities upgrade, maintenance, building security, taxes etc. Including all these cost components will result in a much higher savings in a cloud-based infrastructure model.

The details of Application workloads and Storage and networking requirements considered in above scenario are given in Appendix A: TCO Calculation components and assumptions.

7 VNF Migration to Cloud

Once the decision to move to a cloud based infrastructure is made, an important question that arises is "How do I ensure that the virtual network function when Migrated to the new cloud infrastructure will provide similar or better functionality and performance on my chosen NFV stack?" The process of formulating a successful cloud adoption and migration strategy, and more so, the process of implementing that strategy is not at all easy.

TechM has developed a comprehensive cloud migration framework which is proven from our engagements with telco operators around the globe.

7.1 Industry Approaches for Application Migration

There are different migration approaches available to the Enterprises for applications in their IT & Telco domains, the goal is to bucket the applications portfolio into one of 6 Migration Strategies as shown below. This is applicable for both scenarios - moving to a public cloud infrastructure, or a private/hybrid on-premise platform
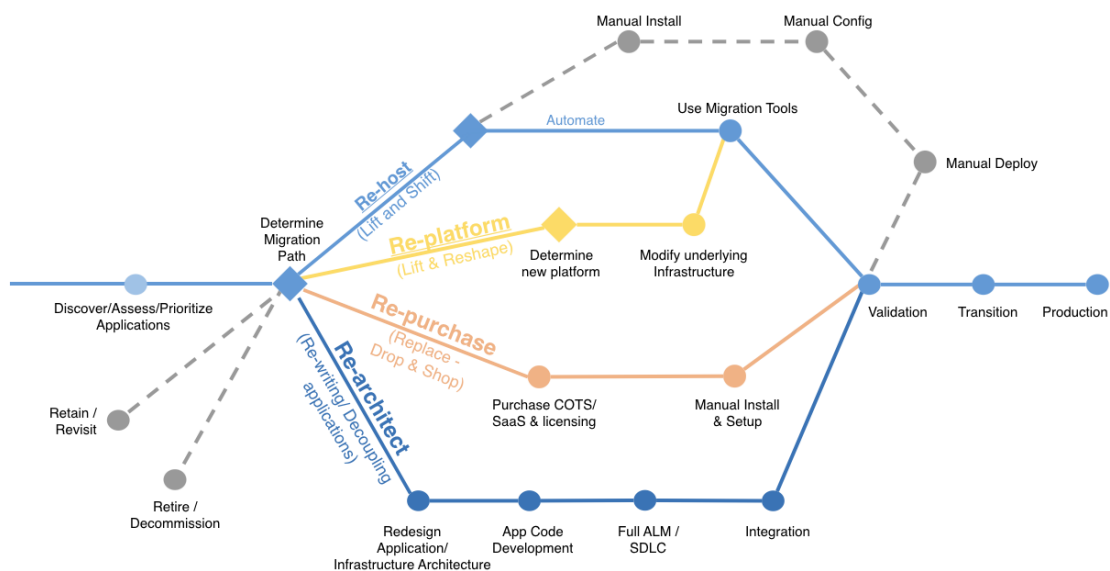

Figure 7-1 Application Migration Strategies: The 6 R's

These approaches differ from simple lift-and-shift to completely refactoring or rearchitecting the applications using cloud native principles. TechM believes that the most optimal Migration Strategy for brownfield Operators would be **Replatforming**, where updated VNFs will be provided by OEMs for new platforms.

7.2 VNF/CNF Migration Key Components

VNF/CNF Migration is a complex process and needs a comprehensive testing and certification framework. This is also an area in which TechM has developed deep expertise and is delivering services to some of leading Tier 1 operators in the world

VNF Complexity Grading: All VNFs need to be analyzed and categorized into low, med, high in terms of complexity along various platform related dimensions such as number of interfaces, compute, network, storage intensity, traffic handling, latency etc. This complexity grading will drive the testing and certification needed for that VNF before migration

Lab design & setup: A fully equipped lab has to be setup having both virtual and bare metal environments, traffic generators, and a test automation framework.

Testing & Certification: Test design, automation, and execution for each VNF. These would include performance benchmarking, VNF/CNF network performance metrics (e.g., throughput, latency, jitter, session scale) and PaaS/CaaS resource utilization statistics under various configurations and user workloads. At the same time Migration execution scenarios also need to be tested.
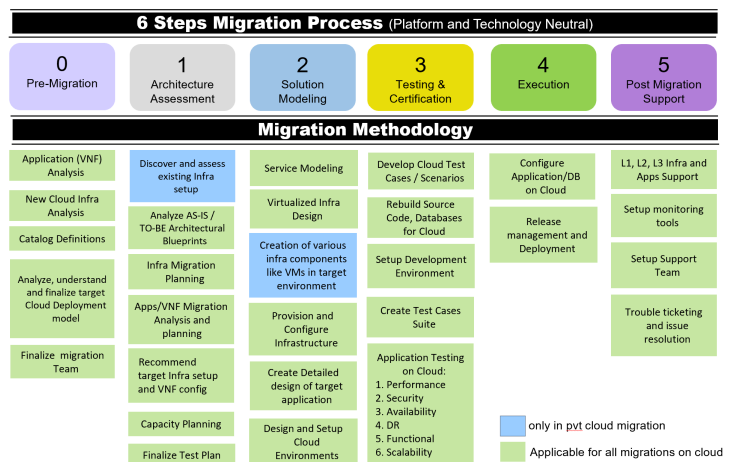

Figure 7-2 Migration Process with Activities

The detailed migration process includes activities as shown in figure

7.3 Performance Benchmarking – KPIs and Metrics

Below are some of the metrics that are used for performance benchmarking of VNF/CNFs and platform performance pre and post migration.

Network Metrics

- Zero-loss packet throughput as percentage of line rate (test defined by IETF RFC 2544)

- Packet throughput with a threshold packet loss (by default = 0.02%)

- Network KPIs as function of system load (packets/sec), measuring latency, delay, jitter, and loss statistics

- Traffic verification, validation of "goodput", (correct packet throughput) in test cases

Infrastructure Platform Metrics

- CPU, memory, network, and storage utilization, as stats collected and archived as time series

- System-level performance stats, such as total simultaneous sessions as function of traffic intensity

VNF/CNF Metrics

- Compute: Sustained and burst bandwidth, error/resend rate, dropped packet rate, CPU utilization, L2Fwd/L3Fwd (North-South and East-West)

- Memory: Memory utilization, kernel time, user space, time, Cache utilization

- Network I/O: Throughput, latency, packet loss

8 Conclusion:

NANC is a revolutionary and World's first offering of its kind! It will enable Tier1 and Tier2/3 Operators to realize their business objectives of Cost, Speed and quality by combining World Class Public Cloud offerings from AWS along with Tech Mahindra's E2E Automation & Orchestration NetOps.ai and Continuous Integrator services.

TechM has drawn upon its deep expertise and experience of providing network professional services to leading Operators around the globe, and its understanding of the needs and challenges faced by today Operators, to build the NANC framework.

For more information, please feel free to reach out to TechM and AWS contacts mentioned at the end of this document.

9 Appendix A: TCO Calculation components and assumptions

The below workloads are assumed in TCO calculation in Section TCO Benefits of NANC, for both On-Premise Data Center and AWS cloud-based infrastructure

Application Workloads

App Name	# of VMs	CPU Cores	RAM (GB)	Hypervisor	GuestOS
AMF	50	32	128	VMWare	Linux
SMF	50	32	128	VMWare	Linux
UPF	10	32	32	VMWare	Linux
NRF	10	8	32	VMWare	Linux
NSSF	2	8	16	VMWare	Linux
NEF	4	16	32	VMWare	Linux
SEPP	2	16	32	VMWare	Linux
UDSF	20	32	64	VMWare	Linux
OPM	2	8	16	VMWare	Linux

Storage

Storage Type	Capacity (TB)	Backup (TB)
SAN	32	64
NAS	32	32
Object (Blob)	16	16

Networking

Bandwidth	Pipesize (Mbps)
Oubound	1000

Table 1 Workloads considered in TCO calculation

The below table gives details on which components are included and excluded in TCO calculation

Cost Component	On-premise	Cloud Based
Server Costs		
Hardware	Included	Included
Software	Included	Included
Storage		
Hardware	Included	Included
Network		
Hardware	Included	Included
Bandwidth	Included	Included
Overhead		
Space	Included	Included
Power	Included	Included
Cooling	Included	Included
Other Facility Costs	Not considered	Not Applicable
IT Labor Costs		
IT Admin	Included	Included
Security Admin	Not considered	Not Applicable
OSS Tools	Not considered	Not Applicable
Operations Staff	Not considered (**major cost**)	Not considered (minimal)

Table 2 Cost Components considered in TCO Calculation

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