Telco Cloud Operations Transformation: Driving Agility and Customer Centricity

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Section 1 : Executive Summary

Waves of digital business transformation have been rippling through different industries over the past few years. Customers are getting used to do online shopping, with their journey all online from product discovery, selection, buying, ordering to payment. As for the Telecom industry, they have their traditional strength in retail, and are currently at the forefront of this digital transformation. By serving customers with both online and offline experience, Communication Service Providers (CSP) are getting their business strategy toward this trend of digitalization in view of the competition with OTT players.

Irrespective of the means and extent of the digitalization adopted by CSPs, Customer Centricity and Service Agility are the two prime focuses in the course of digitalization. For the purpose of agility, network cloudification is the key technology enabler for the digitalization.

In May 2016, HKT & Huawei formed a partnership to kick start the digital business transformation project - Project Earth. Project Earth is a customer centric digital business transformation project, in which HKT has adopted an end-to-end approach, including service transformation, business process transformation and network transformation. Alongside cloud based network management and control, a new Business Support System (BSS) and Service & Resource Design, Orchestration & Assurance Capability are introduced to deliver service and operation management . By the end of 2017, HKT has successfully achieved the milestone of pre-commercial launch of the first phase of Project Earth with live paying customers.

In this digitalization project, one key success factor is to design and implement a new operational model for the transformed network infrastructure. Successful implementation of this project relies on a careful review of all operational aspects, from technology to team organization.

This whitepaper describes the Operations Transformation that HKT and Huawei have transformed themselves throughout the project, the outcomes and changes adopted, and the preparation of up-coming evolution that will bring operational capability of HKT toward another step forward.

Section 2 : NFV & Cloud Infrastructure Deployment – HKT & Huawei Partnership Project

HKT has adopted Customer Centricity as a key focus in the project.

To HKT, it involves an end-to-end transformation from service, business processes to network cloudification. Figure 1 gives a high level illustration of the approach taken by HKT in Project Earth.

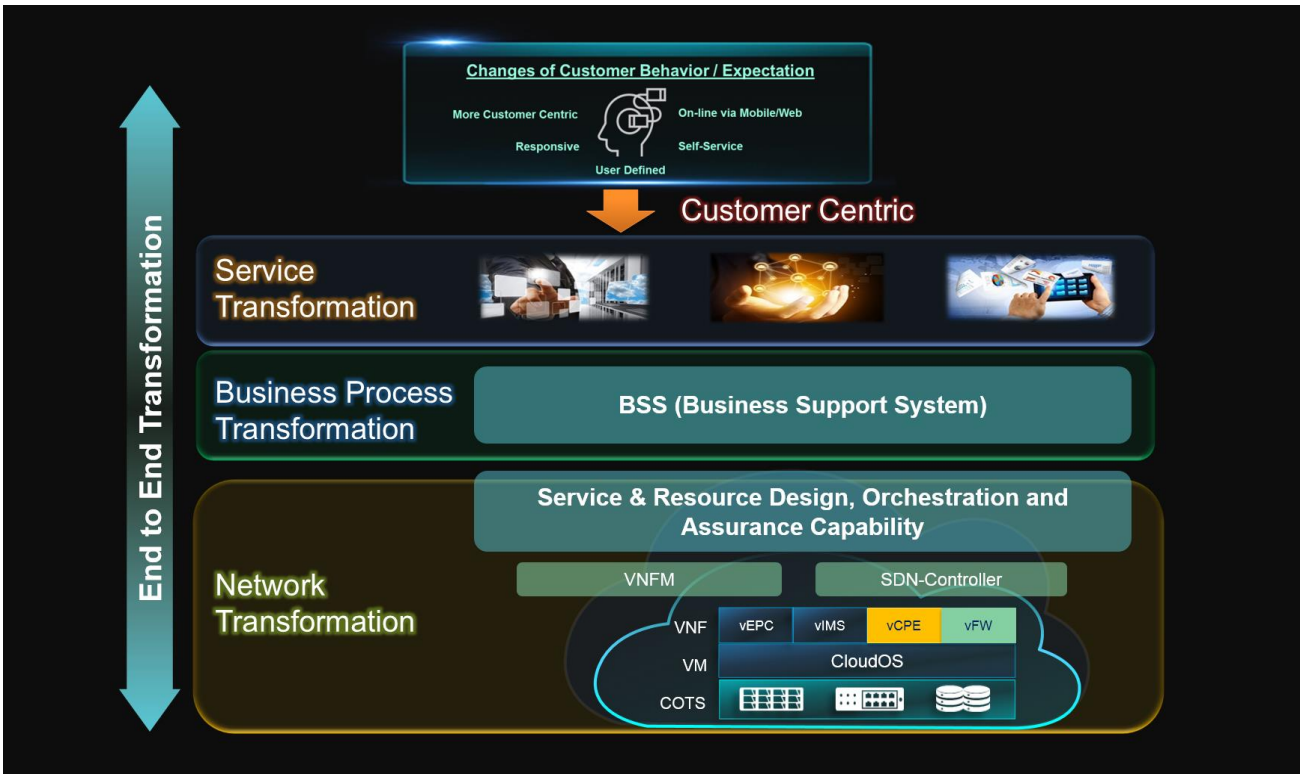

Figure 1 Approach of HKT Digital Business Transformation

2.1. Network Transformation - Telecom Cloud Architecture

The high level architecture of a cloud based infrastructure in Project Earth is illustrated in Figure 2. In short, it is composed of two main components:

a) **Business Support System (BSS):** this is where the business processes and customer interfaces are implemented. A customer portal, service related processes and billing integration are included in this platform.

b) **Cloudified Network**: the Cloudified Network consists of the Service & Resource Design, Orchestration and Assurance Capability, VNFs (vPGW, vIMS, etc.), NFVI (COTS + CloudOS) and the SDN. The VNFs perform the same network function as PNFs in today legacy network while NFVI layer offers the virtualized hardware resources for the VNFs. The Service & Resource Design, Orchestration and Assurance Capability has two functions. On one hand, it accepts the service order from BSS via RESTFUL API and orchestrates the VNFs and SDN to

fulfill the service requests. Mobile CloudVPN, a new service developed on this platform (which provides the environment to carry out the Service & Resource Design, Orchestration and Assurance Capability) , is an example in which the platform takes the service order from BSS, request NFVI layer to create the network resources (vCPE and vFirewall), put through the tunnel connection by sending commands to SDN.

On the other hand, the Service & Resource Design, Orchestration and Assurance Capability platform also performs network assurance functions which will be further elaborated in subsequent sections of this whitepaper.

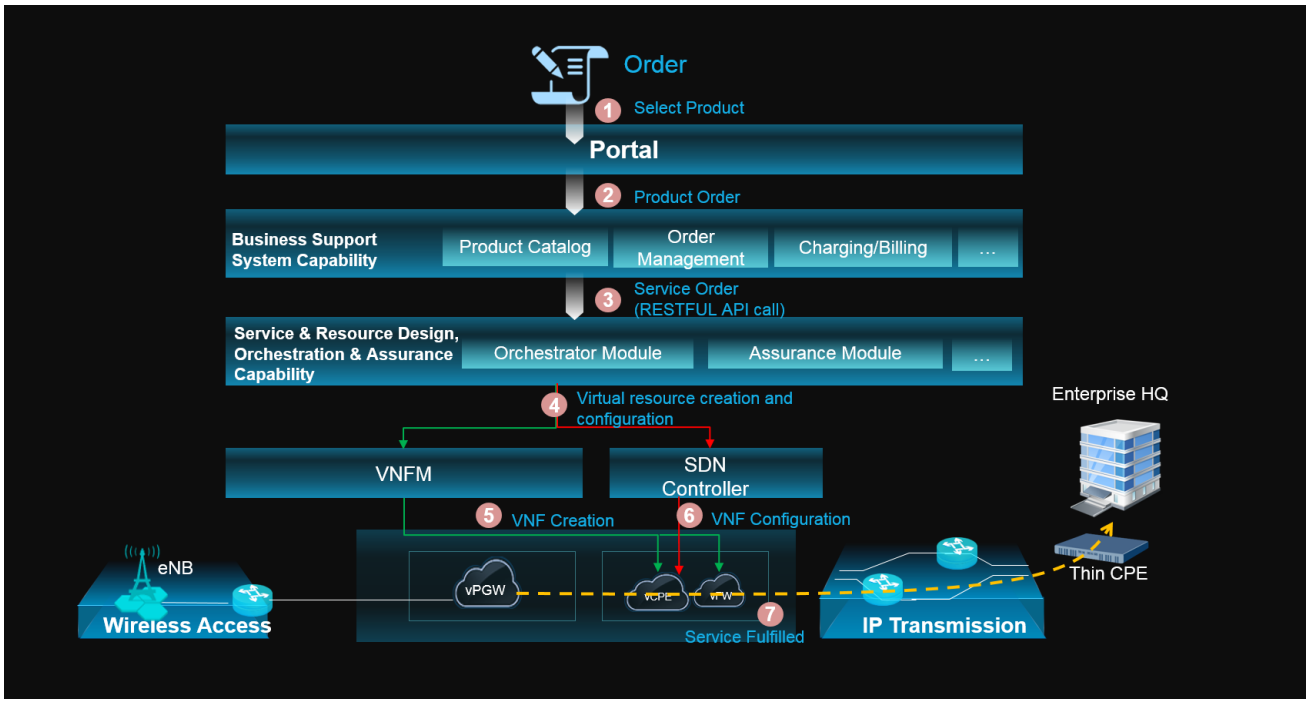

Figure 2 High Level Architecture of Cloud-based Infrastructure in Project Earth

2.2. Operational Challenges

While the Cloudified Network enables the transformation on user experience, it also brings in new challenges to the network operations team. Here are some of the challenges.

a) Fault Management in a virtualized network

Instead of running a PNF on a dedicated hardware platform, all VNFs are now running on a shared layer, NFVI. Multiple network functions reside on the same COTS platform supporting the NFVI layer. In the case of PNF, the fault on hardware platform is specific to that PNF. However, in the case of VNF, the fault on COTS platform would induce multiple faults to VNFs which it is supporting VNFs. Operations team may be confused, and as a result, the troubleshooting time is prolonged.

b) Fault Management in multiple network entities

New service such as Mobile CloudVPN involves multiple network entities, vCPE on client side, and metro links with CPE on enterprise server side. Its path also spans across fixed and mobile network operation domains. It substantially increases the complexity of fault isolation and recovery. This will also be affected by how operations teams in managing common resource layers (i.e. the platform for Service & Resource Design, Orchestration & Assurance Capability, NFVI, SDN), and collaborating with various teams who are managing other network functions (e.g. vPGW, vIMS).

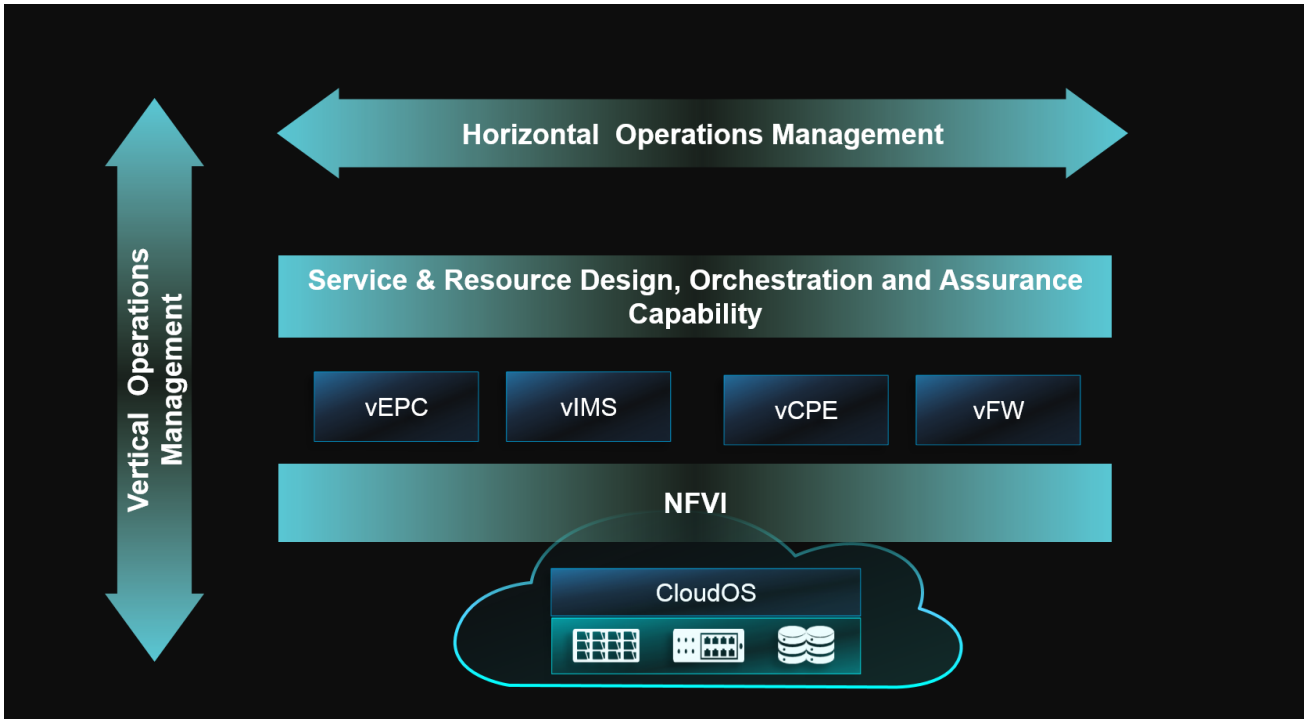

Figure 3 Cloudified Network brings in new Operation Model

c) IP network management

Virtualization of network entities will inevitably introduce a large number of independent nodes (i.e. VMs) over the IP network. It is unrealistic and unmanageable to manually configure the IP connectivity among such a large number of nodes, given that additional design policies, such as VLAN isolation, have to be taken care as well.

d) IT technologies

Cloud based Telco infrastructure is a form of adaptation of IT technologies into the telecom world. This brings challenges to the operations teams to manage these new technologies, demanding new skills and a new mindset to support the new cloudified infrastructure.

These challenges cannot be tackled solely by introducing management systems or automation. The optimization of the process flow and organization are considered in term of new staff knowledge and skill set training, which are vital to the seamless operation during the migration from the operation of existing legacy network to the new cloudified network operation.

Section 3 : HKT Operations Transformation

After reviewing the challenges and their potential impact on the success of Project Earth, HKT and Huawei decided to tackle them with a comprehensive operations transformation. A joint workgroup has been established, consisting of operations experts and system architects from both companies.

A few guiding principles have been established in the workgroup:

a) Operational solutions and processes shall be developed from an end-to-end perspective, aiming at "closing the loop" (the close loop control mechanism in place from the beginning of the requests initiation with the problems reporting, the operations team have to register, follow up, handle the solution, problem fixed before the request can be closed);
b) The operations teams will take care of the new Cloudified Network, in addition to the existing legacy network;
c) Services running on the Cloudified Network shall have at least at par with the quality level as those running on the existing legacy network;

3.1. Operations Transformation Methodology

The workgroup has adopted the following methodologies in this project:

a) Identifying Transformation Dimensions

All activities and tasks in network operation can be attributed by four operational dimensions, namely, Metrics, Process, Technology, and People & Organization, as shown in Figure 4. Requirements, problems and solutions will be developed along these four dimensions:

- Metrics: The measurements which drive the performance of the business units, teams, and people
- Process: The end-to-end activities that create measurable outputs
- Technology : The tools, both enablers and applications, that are critical to business success, including IT Systems
- People & Organization: The profile of the employees including all competencies and how they are structured in the organization

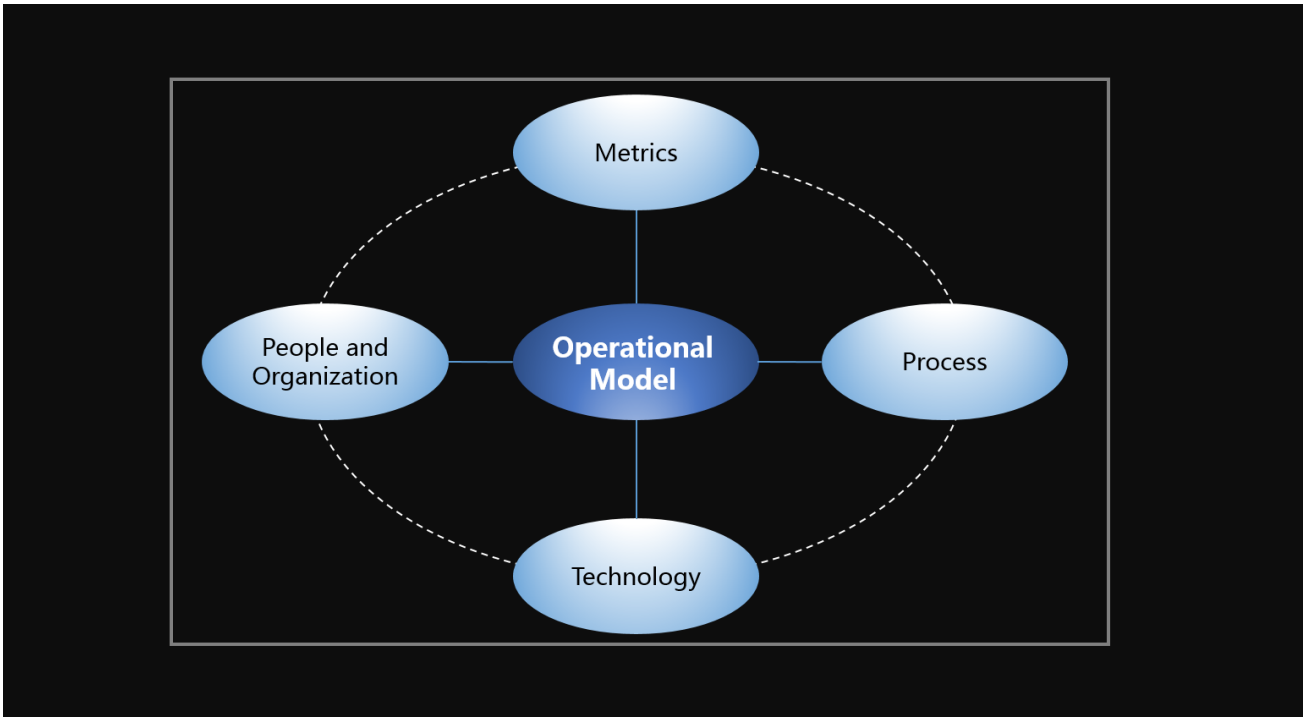

Figure 4 Operational Model

b) Breakdown to Project Stages

The transformation project is broken down into stages. In brief, it started with a thorough study of the existing situation, followed by prioritizing the gaps against future needs, and completed with solution delivery and implementation.

In the course of operations transformation, process revamp and technology adoption are given priority over people & organization optimization. Subsequently, the three work streams will evolve iteratively and converge at the end of optimization. SLA and performance metrics will be reviewed after initial launch.

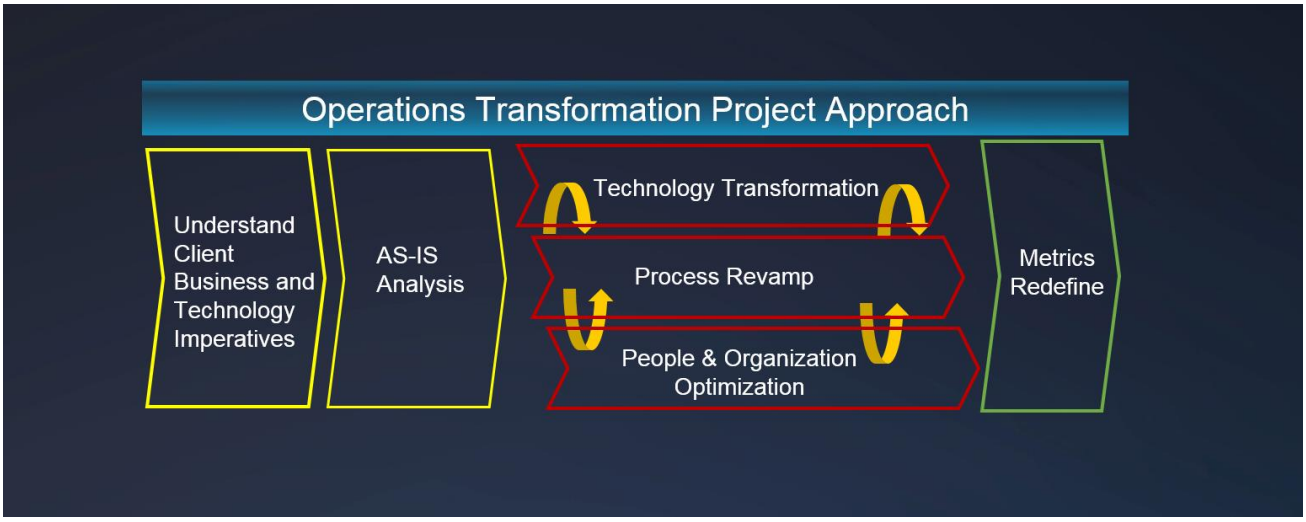

Figure 5 Project Approach for Operations Transformation

c) Establish an End-to-end Process Reference

In the operational process analysis and design track, the project team cross referenced HKT processes and workflows against industry standards. Cross referencing to IT industrial standard (i.e. IT4IT™ Reference Architecture [1]) together with telecom operating model (i.e. eTOM [2]), the project team identified the impacts on existing operational framework, and then defined the operations transformation scope. This is to ensure that new processes will have comprehensive coverage to avoid any missing pieces.

3.2. Technology Evolution

To operate this multi-layered network effectively and efficiently, HKT and Huawei designed and deployed the Infrastructure Enabling System (IES, which provides the environment to carry out the Service & Resource Design, Orchestration & Assurance Capability) to consolidate and coordinate all management sub-systems in cloudified network of HKT. IES provides a unified management environment for the Cloudified Network, and also acts the integration point with the existing centralized network management platform of HKT.

Figure 6 shows the high level block diagram of different management modules in HKT cloudified network.

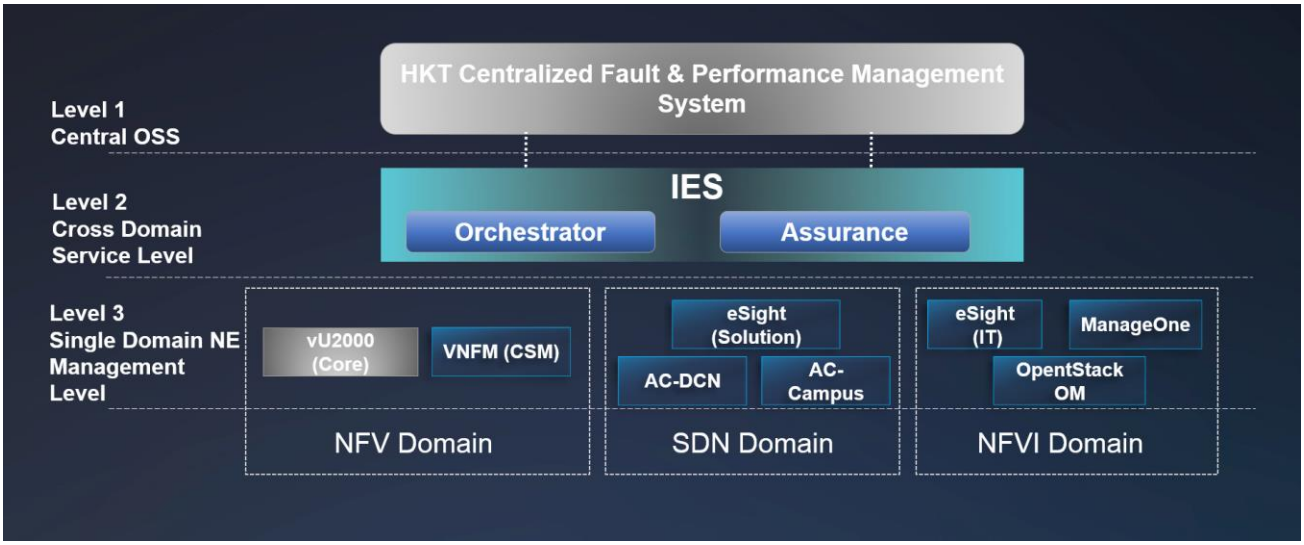

Figure 6 Various O&M Systems in HKT Cloudified Network

a) Centralized Telecom Cloud Management

IES is introduced as the focal point of management functions for the entire Cloudified Network. IES integrates with all management subsystems (EMS, Controllers etc.) at different layers of network stack. It provides comprehensive Fault, Performance, and Configuration management functions through its Assurance and Orchestration modules.

Besides, IES being the focal point of the Cloudified Network, its northbound interface serves two functions. It integrates with HKT's enterprise BSS platform on service management, and OSS platform to ensure the NOC can have the "Single Pane of Glass" view across the whole network.

b) Cross Layer Event Correlation

IES collects alarms, performance data and all types of events from its southbound systems and provides an integrated view to operations teams. But this traditional approach cannot contain new challenges on assurance under NFV/SDN architecture, i.e.

- Volume of alarm generated will likely be higher with another layer of virtualization
- Decoupling of network function from infrastructure layer will increase difficulties in problem isolation

Root Cause Analysis (RCA) function is hence developed in IES to tackle these challenges. Base on IES's network topology database, RCA associates incoming alarms with different managed objects. Since topology database is maintaining the relationship among service, network, and infrastructure objects, outstanding alarms on each network node and its underlying infrastructure node can be intuitively visualized.

Furthermore, RCA also maintains a set of alarm rules that define the "Parent-Child" relationship among common alarm scenarios. If an alarm pattern matches certain rules, the root cause alarm (Parent) will be identified, and associated alarms (Child) will be suppressed. This function will

help to shorten the time and improve the accuracy on problem isolation.

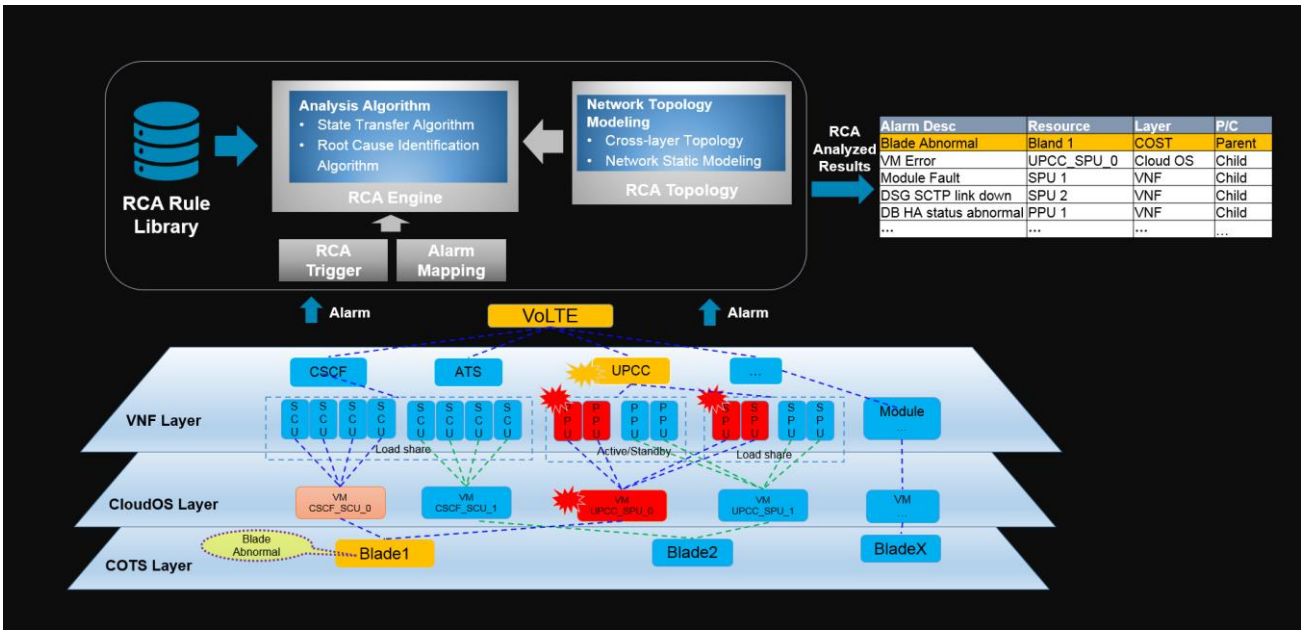

Figure 7 Root Cause Analysis (RCA) Use Case

c) Coordinated VNF and DCN Orchestration

One of the purposes of deploying network functions on cloud based network is to enjoy high agility in network/service deployment, and scaling thereafter. To achieve this goal, an end-to-end automation of VNF creation and corresponding IP network configuration are essential capabilities.

The crucial point is to orchestrate these two processes in a coordinated manner, thereby, to achieve an end-to-end network/service deployment automation. Huawei has realized such orchestration capability on IES. This capability is pivotal to large scale VNF deployments to ensure accuracy and efficiency of change. The orchestration functions will also be used in the assurance processes to "close-the-loop" from fault detection, problem isolation, to service recovery.

d) Tenant Based End-to-end Service Surveillance

One distinct feature of IES is to employ data models and templates to define a service. This enables IES orchestrator to support a larger variety of service options and topologies, which can be customized for different customers (tenants).

This database of service options and topologies is also instrumental in the assurance processes. Taking Mobile CloudVPN service as an example, IES assurance module is "aware" of the topology configured for each tenant and able to associate alarm, usage and performance information with it. Figure 8 gives an example showing the surveillance of Mobile CloudVPN service in a Mobile-to-Internet (M2I) topology. This alarm status view will be intuitive for customer support

personnel to visualize the situation, drill down to examine network node status, and isolate the problem.

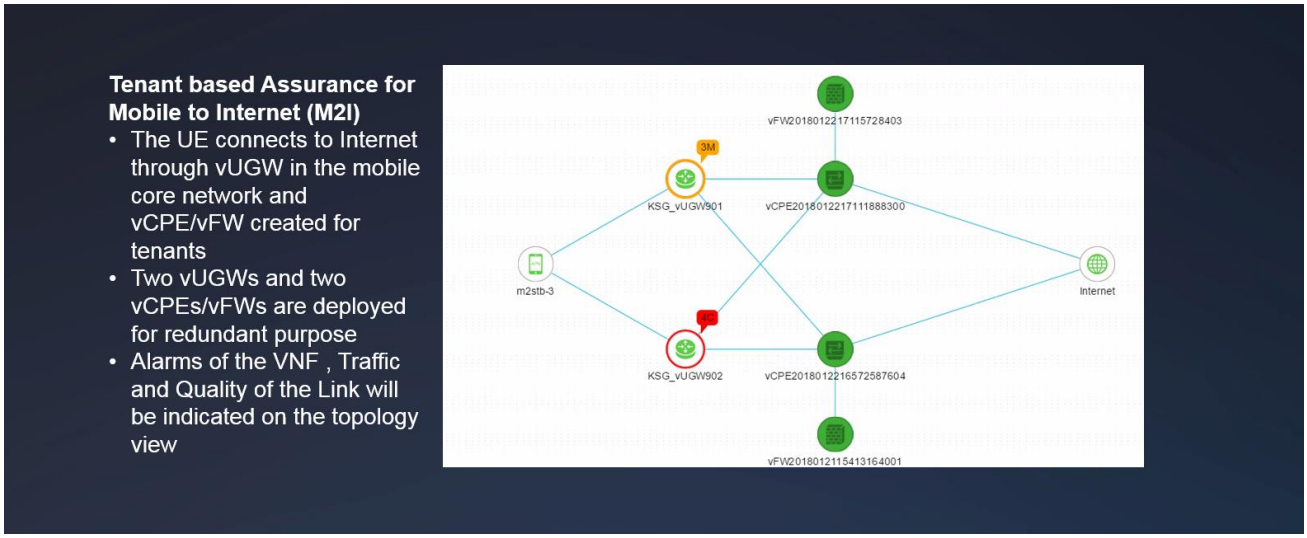

Figure 8 Tenant Based Surveillance

3.3. Process and Workflow Revamp

Service, architecture and technology changes mentioned above imply that the operations environment will be changed correspondingly. This has triggered the O&M process revamp.

During the “as-is” analysis stage, both HKT and Huawei concurred that it is necessary to choose an appropriate methodology to guide the operations transformation. The IT4IT™ Reference Architecture and eTOM operating model have been adopted as the framework for process redesign.

After breaking down existing operation processes in HKT, the team consolidated the processes across the four value chains, namely, Strategy, Implementation, Fulfillment, and Assurance as shown in Figure 9, to analyze and identify critical changes brought by the Cloudified Network and new services.

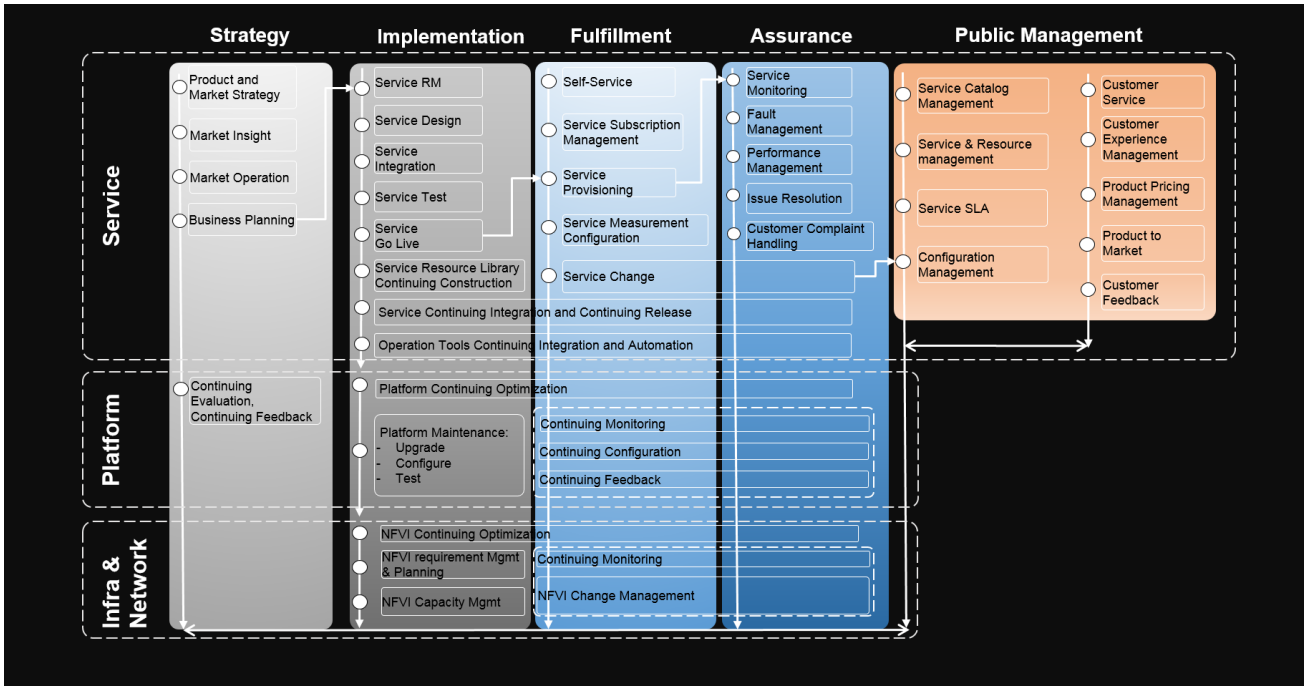

Figure 9 HKT Operations Framework Breakdown

The team further looked into details of each process to explore the major variations between the "cloudified" operation model and its existing ones.

After studying and analyzing, the team found that the basic operation framework is similar to the existing one. However, activities in some processes will be changed due to the introduction of new network, new technologies, new services and new platforms. Through the analysis, the team has identified seven crucial operations processes that require a revamp.

Table 1 shows the key changes for seven processes under the cloudified operation environment.

Table 1 Key changes for Affected Processes

Category	Process	Key Changes
Service	Service Provisioning	• End-to-end automated orchestration - multi-layer and cross-domain • Enabling real time ordering and activation
	Customer Complaint Handling	• Based on service monitoring to recognize possible service issues proactively • Multi–layer, cross-domain RCA increase trouble ticket efficiency
	Service Design	• Continuously and rapidly design and develop assurance applications to meet various O&M purposes • Enable design, verification and deployment of end-to-end cross-domain service templates via the service design environment
	Service Monitoring	• Centralized management for fault, performance and logging for the overall telecom cloud network • Multi-layer monitoring with enhanced efficiency using RCA • Proactive monitoring and diagnosis for tenant based

		end-to-end services
Platform	System Maintenance	• More focus on rights and domain-based management, to ensure operations safety • Exceptions captured in IES from SBIs and NBIs are critical for end-to-end service orchestration
Infra & Network	Change Management	• Automated network deployment and changes can performed by new platforms • Team collaboration is more important in multi-layer architecture than it is in the legacy network
	Capacity Management	• Periodic and unified resource planning across different domains • Analyze and predict resource utilization trends to optimize utilization rates • Automation in resource expansion via monitoring process

Once the scope had been defined, the team refined the corresponding process under specific scenarios:

- Modified existing workflow or redesign the process and specific procedures
- Identified new responsibilities and assignment of new roles
- Consolidated the above two into the Standard Operating Procedures (SOP)

To an operations team who will both take care of the existing and new cloudified network, a well document SOP is very crucial. Not only will it contains the exact step by step procedures to be carried out, the SOP also outline the roles and responsibilities of different teams along the process, and the supporting tools/systems to be used. All these have to be well defined to ensure accuracy, consistency and avoid confusion by existing practices.

3.4. People & Organization Alignment

Following operation technology and process revamp, changes to organizational roles and people skills has been addressed. From the review, for instance, “Service Template Designer” is one of the newly identified roles responsible for the design and editing of end-to-end service templates.

In order to minimize the risks and impact incurred from operational changes, HKT has adopted the following principles:

- Instead of creating a green field unit, the operations of the Cloudified Network will be carried out by existing operational staffing
- Operations team functional responsibilities and support capabilities will be enhanced in a step by step manner which is in line with network and management systems evolution
- Responsibilities will be assigned to the corresponding operational units according to domain expertise and technical relationship. For example the IP operations team will be responsible for the operations of the SDN network, the EPC/IMS operations team will take care of the support and management of VNFs as well as existing PNFs.

Figure 10 below highlights the generic approach to develop the necessary capabilities from both resource and skill set point of view.

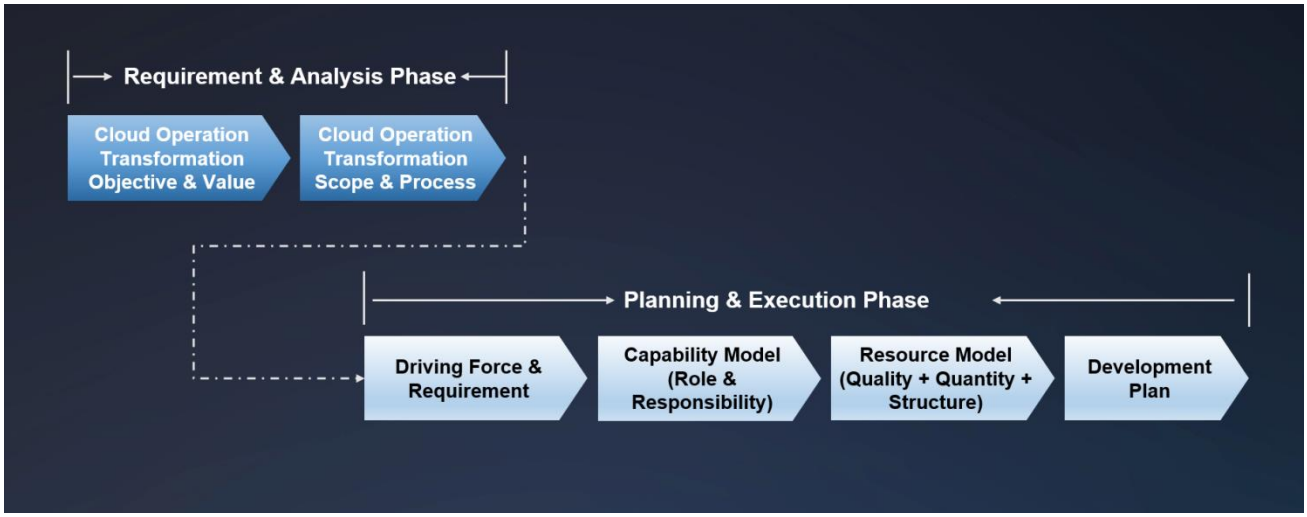

Figure 10 Capability Development Approach

At the start of the project, the workgroup conducted detail study on existing operation organization, roles and responsibilities of different teams, job demarcation and staff duties. When the new operation processes for Cloudified Network are drafted, they are matched against each other. Redesign or adjustment can happen on either the process or role side. Once the roles and responsibilities are defined, a team capability development plan is developed with following elements in it:

- **Driving Force & Requirement**: a set of operational requirements under the cloudified operation environment.
- **Capability Model**: the model elaborates the necessary skill sets to operate the network and services.
- **Resource Model**: the model elaborates the necessary resources to support daily operations.
- **Development Plan**: the plan for capability and resource development including training schedule, training program, etc.

Section 4 : Heading Towards the Future Operations Mode

With the introduction of the new BSS, Service & Resource Design, Orchestration & Assurance Capability and NFV/SDN in Project Earth, an end-to-end automation of service fulfillment is now possible. Moving forward, HKT will further automate the operations processes, and continuously improve on operation agility.

Self-healing is an important aspect of operational automation. When a fault has been identified, service can be restored and the fault can be resolved automatically according to pre-defined rules and policy settings. The Service & Resource Design, Orchestration & Assurance Capability is equipped with a Service Design environment which provides function for operators to define the policies required in the self-healing, and passing it to the assurance runtime for execution.

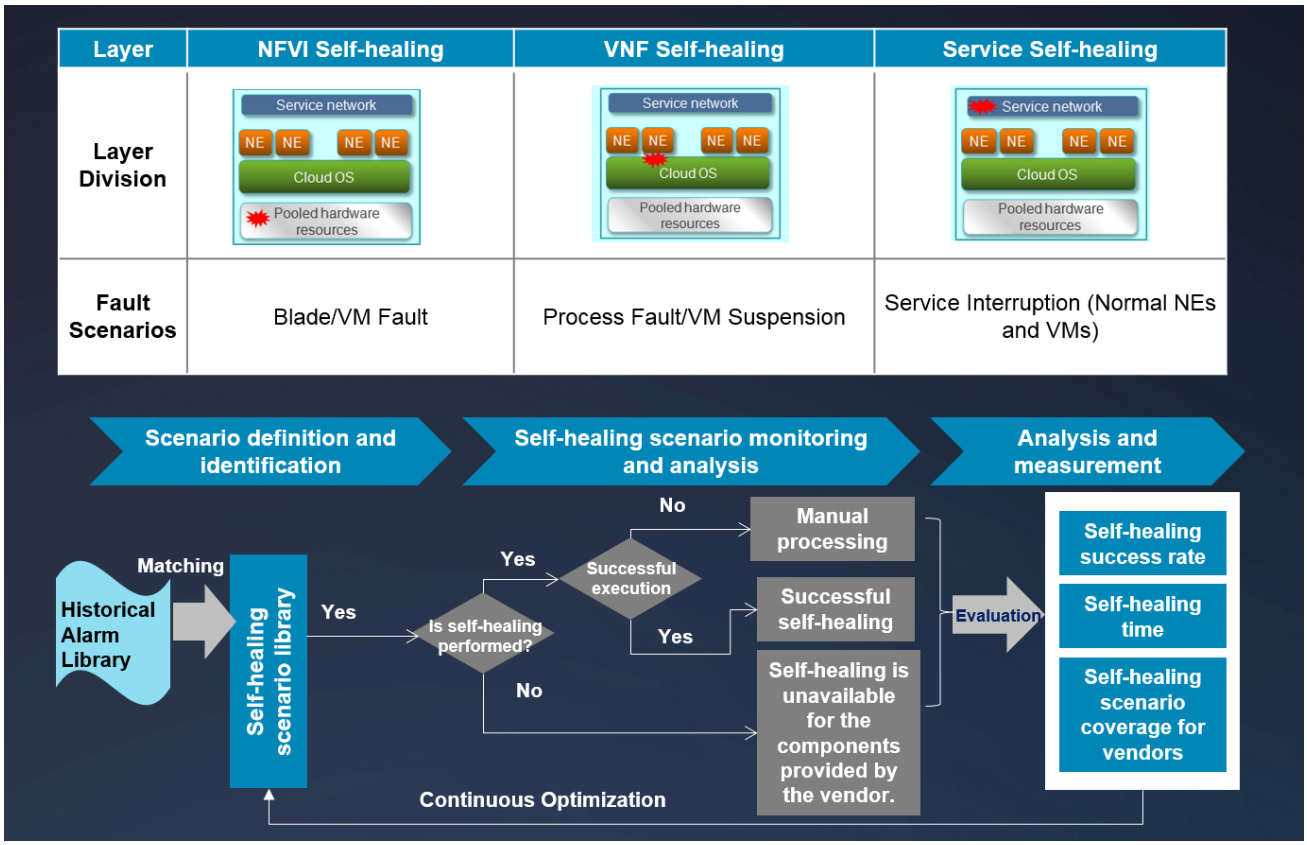

Figure 11 Self-healing for the Telecom Cloud Network

Closed-loop Analysis of Service Quality Deterioration starts with monitoring on QoS. Once a specific KPI degradation is identified, it will automatically trigger the analysis process to analyze the cause of the event. Closed-loop service quality control can be achieved through automatic detection, problem analysis, fault isolation and recovery in some cases.

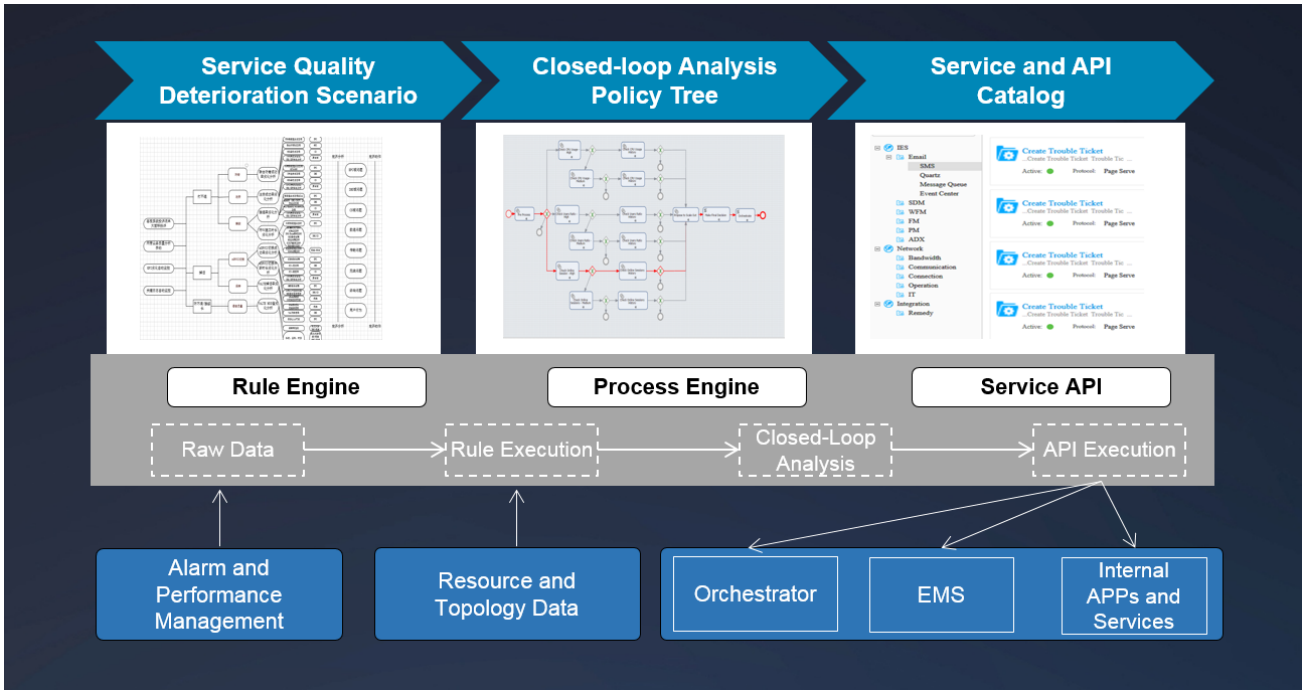

Figure 12 Closed-loop Analysis of Service Quality Deterioration

Section 5 : Conclusion

An NFV/SDN based telco cloud infrastructure is implemented in HKT under Project Earth with end-to-end service automation and orchestration capabilities. This empowers HKT with the agility and flexibility to capture new business opportunities in a customer centric manner.

Operations transformation is vital for HKT to contain and manage the architecture & service complexity brought about by new technologies, while maintaining (or even uplifting) service quality and efficiency.

In the course of operations transformation, HKT has implemented:

- An automatic orchestration layer to streamline cross-domain and multi-layer service operations
- Root cause analysis for alarm management to speed up multi-layer platform problem resolution
- A process and organizational review to design the right workflows and to develop staff with the right skill sets

Through this project, HKT and Huawei have gained first-hand experience on NFV/SDN cloud deployment, service design and roll out, and the whole operation transformation journey. Practical use cases, examples and details for telco cloud operation have been realized in a commercial environment. The Operations Transformation taskforce will continue to drive further results in future, fueled by an ongoing collaboration between both companies.

Section 6 : Index of Acronyms

BSS	Business Support System; The platform provides customer management, product management, order management, customer service and insight, revenue management etc. in order to support CSPs E2E business operations to improve revenue, profit, operational efficiency.
CloudOS	Cloud Operating System; A cloud operating system is a type of operating system designed to operate within cloud computing and virtualization environments. A cloud operating system manages the operation, execution and processes of virtual machines, virtual servers and virtual infrastructure, as well as the back-end hardware and software resources.
COTS	Commercial Off-the-Shelf; It is a term for software or hardware, generally technology or computer products, that are ready-made and available for sale, lease, or license to the general public.
CPE	Customer Premises Equipment; Customer Premise Equipment is service provider equipment that is located at customer's premises
CSP	Communication Service Provider; A service provider that transports information electronically—for example, a telecommunications service provider. The term encompasses public and private companies in the telecom (landline and wireless), Internet, cable, satellite, and managed services businesses.
EMS	Element Management System; ITU-T compliant software that is used to manage one or more specific types of network element (NE). An EMS enables a user to individually manage all the features of each NE, but not the communication between NEs. This communication is managed by the network management system (NMS).
EPC	Evolved Packet Core; A framework for an evolution or migration of the 3GPP system to a higher-data-rate, lower-latency, packet-optimized system that supports, multiple RATs.
IES	Infrastructure Enabling System; The platform provides the environment to carry out the service design and creation, orchestration and assurance capabilities.
IMS	IP Multimedia Subsystem; A standardized Next Generation Networking (NGN) architecture for telecommunications carriers who want to provide mobile and fixed multimedia services.
KPI	Key Performance Index; The KPI indicates the performance value of an object at a certain time point. A KPI may be obtained by the aggregation of multiple levels of KPIs.
NFV	Network Function Virtualization ; Aims to transform the way that network operators architect networks by evolving standard IT virtualization technology to consolidate many network equipment types onto industry standard high volume servers, switches and storage, which could be located in Datacenters, Network Nodes and in the end user premises.
NFVI	Network Function Virtualization Infrastructure; A collection of computing, storage, and network resources required for network function virtualization.
NOC	Network Operation Center; It is also known as a "network management center", one or more locations from which network monitoring and control, or network management.
O&M	Operations and Maintenance; Covers all aspects and activities necessary to run your facility/network/systems/services in a safe and stable manner.
OSS	Operations Support System; It is originally used in the telecommunication world to describe the processes and teams that monitor the underlying networks. Predominantly looks after the functional and non-functional requirements of solutions/systems. Monitoring, end-to-end design, and error handling tend to be the main areas of work.
PGW	Packet Data Node Gateway; Packet Data Node Gateway acts as the interface between the LTE network and other packet data networks; manages quality of service (QoS) and provides deep packet inspection (DPI).
PNF	Physical Network Function; An implementation of a NF via a tightly coupled software and hardware system.

QoS	Quality of Service; A commonly-used performance indicator of a telecommunication system or channel.
RCA	Root Cause Analysis; A method of problem solving used for identifying the root causes of faults or problems.
SDN	Software Defined Networking; An approach to networking in which control is decoupled from hardware and given to a software application called a controller.
SLA	Service Level Agreement; A service contract between a customer and a (SLA) service provider that specifies the forwarding service a customer should receive.
SOP	Standard Operating Procedure; A set of step-by-step instructions compiled by an organization to help workers carry out complex routine operations.
VIM	Virtualized Infrastructure Manager; It is responsible for controlling and managing the NFVI compute, storage and network resources.
VLAN	Virtual Local Area Network; A logical grouping of two or more nodes which are not necessarily on the same physical network segment but which share the same IP network number. This is often associated with switched Ethernet.
VNF	Virtual Network Function: A software-based version of a legacy Network Function running on a virtualized environment. Consists of one or more virtual machines/containers running different software and processes, on top of standard high-volume servers, switches and storage devices, or even cloud computing infrastructure.
VNFM	Virtualized Network Function Manager; It is responsible for the lifecycle management of VNFs. VNFM operations include: – Instantiation of VNFs, – Scaling of VNFs – Updating and/or upgrading VNFs – Termination of VNFs
VM	Virtual Machine; It is an emulation of a computer system. Virtual machines are based on computer architectures and provide functionality of a physical computer. Their implementations may involve specialized hardware, software, or a combination.
VPN	Virtual Private Network; A system configuration, where the subscriber is able to build a private network via connections to different network switches that may include private network capabilities.

Section 7 : References

[1]	The Open Group IT4IT Reference Architecture, http://www.opengroup.org/it4it/about
[2]	The TM Forum Business Process Framework, https://www.tmforum.org/business-process-framework/