The vEPC Use Case

Rebaca

ENSURING QUALITY ON SCHEDULE

INTRODUCTION

Networks are changing and adapting according to the services that subscribers demand. Along side, lies the network's capability to provide seamless new services every day. In the midst of all this transformation, **the service provider's biggest challenge is to meet the high standards of subscriber expectation.**

We can categorize the fast-evolving needs of the Telecom Service Provider network into the following areas:

- Mobility
- Security
- Load and Resilience
- Services (Co-existence of Old and New)
- Energy
- Obsolete Technology (Re-Use Cases)
- Billing
- Operations
- Upgrade

Rapid advances in radio access technology have solved the need for mobility. Security requirements have also advanced in terms of cryptography and protocols to support the same. Services have evolved from basic voice and text, to the all too familiar requirements for video consumption nowadays. IoT and M2M are the next generation services that shall be of interest in the near future. Artificial Intelligence built inside the Telecom Network shall be the next big step in the not too distant future. Obsolete technology is being re-purposed, like Giga Wire launching Ultra-Broadband (1Gbps) network over existing Copper Wire networks. Billing infrastructure has evolved to support the new services and processes.

However, some categorical needs have not yet been addressed. These are operational costs and resource optimization from the perspective of load, resilience and energy. We thus arrive to a real use case of vEPC. **The concept of the cloud and NFV architecture helps solve the problem of optimal resource utilization to reduce operational costs.** The NFV architecture and the standards set for VNF lifecycle management by ETSI cater to these needs of the network.

EPC solves the problem of ubiquitous and intelligent forms of data. But **vEPC solves the problem of dynamic and horizontal scaling, based on subscriber needs for new and existing services. Thus, vEPC in the NFV ecosystem addresses Network Load and Resilience challenges** along with the other categories mentioned earlier

NETWORK LOAD

In terms of Telecom Network use case, what contributes to the load characteristics of the network?

The Virtualization Use Case

In Korea, the top 10% of subscribers who make the heaviest use of the 4G network's resources account for 58.5% of total traffic.

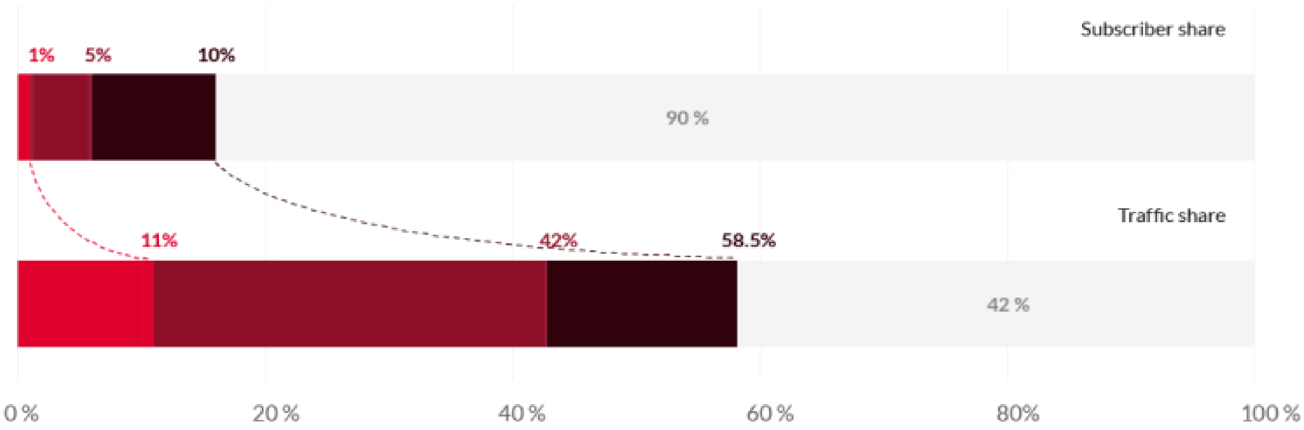

Figure 1 (Source: netmanias.com)

Figure 1 shows a reference to data provided by the most advanced LTE society in the world. South Korea has the highest penetration of LTE in the world along with Japan. This graph also sights that 90% of the subscribers in the network are not heavy internet users. That means that all over the world, idle mode is the most popular mode of LTE operation. The idle mode is the purest mobility use case where the load being exerted on the network is only because of the user moving. The information in Figure 1 suggests that mobility application traffic from idle mode would account for the highest amount of signaling traffic. This is not the case according to studies from Oracle Communications. The study revealed the following figures:

Category	Projected for 2019 Messages Per Second (MPS)	Growth Rate (per annum)
Mobility (LTE Broadcast)	21 Million	66%
Connected Car	75 Million	41%
VoLTE	81 Million	42%
Basic Policy	390 Million	59%

Table 1 Source: Oracle Communications

Mobility is the primary driver or trigger for all the signaling traffic in the network. But it doesn't hold the prime share of network traffic from a use case or service perspective. **The real traffic load generator is the Diameter based traffic generated by the basic policy engines in the network.**

Now, let's look at projected spending in VNFs categorized by service:

	Worldwide Service Revenue (US$M)			2014-2019
	2014	2015 (E)	2019 (E)	CAGR
NFV	**$ 951**	**$ 2,264**	**$ 11,602**	**65 %**
Hardware	**$ 153**	**$ 364**	**$ 1,806**	**54 %**
NFVI Servers, Storage, and Switches	$ 153	$ 364	$ 1,806	54 %
Software	**$ 177**	**$ 1,847**	**$ 9,409**	**65 %**
NFV MANO	$ 13	$ 79	$ 768	125 %
VNF	$ 758	$ 1,767	$ 8,642	63 %
PCRF and DPI Functions	$ 553	$ 1,030	$ 3,153	42 %
Mobile Core and EPC Functions	$ 74	$ 218	$ 2,088	95 %
IMS Functions	$ 89	$ 396	$ 1,719	81 %
Security Functions	$ 37	$ 79	$ 421	63 %
vRouters	$ 2.5	$ 21	$ 271	156 %
Video CDN Functions	$ 0	$ 10	$ 301	N/A
Other	$ 1.5	$ 15	$ 688	242 %
Software	**$27**	**$ 53**	**$ 387**	**71 %**
Outsourced Services for NFV Projects	$27	$ 53	$ 387	71%

Table 2 Source: Intel

We can clearly see that projected spending in VNFs in specific areas is correlated with Table 1, which specifies the performance requirements of communications networks in the near future. There is a clear distinction between the need for resource optimization and the need for NFV based cloud platforms.

From data of various Service Providers, we can infer that there is a serious need to address Diameter messaging in Telecom Networks. This doesn't mean the other service use cases of vEPC – Mobility, Connected Car, VoLTE need to be ignored. The Oracle Communications study doesn't mention figures for other unpredictable **IoT and AI applications** that might arise apart from the well documented connected car use case. As a matter of fact, any currently unforeseen use case **may cause a considerable spike in mobility traffic, possibly a higher spike than Diameter traffic.**

The vEPC use case
WHITEPAPER

Another dimension to the load characteristics are unforeseen use cases that are real pain points of Service Providers:

- **Disaster Events**
  Storms, floods, earthquakes, public utility outages, and terrorist attacks can cause a spike in traffic on the Service Provider Networks

- **Failure**
  Small scale (Functional or Hardware)
  Large Scale (Network, Data center, Geographic Center)

Network Service Providers are constantly trying to find new ways to fathom unpredictable situations. **Methods to simulate load for disaster, failure and things of such nature with analyzable results is of paramount importance.** This can help achieve the desired resilience characteristics to guarantee a seamless subscriber QoE.

In order to reduce the risk of exposure, the following are the options that the Service Provider has at its disposal:

Function Specific Redundancy and Resilience

Classification of services in the network has been a long standing requirement to provide resilience for different services. Implementing this requires the network to have elastic capabilities of reorganization. **Without elastic capabilities, the solution only provisions for redundant servers within or across geo-locations for particular service(s).** Thus Cloud provided elastic capabilities are best achieved by virtualization of network functions. This leads to the actual clusters in the network that are required based on service classification. **Service specific clusters also have dynamic requirements of spinning up/down based on popularity and regulatory constraint needs.** The strategy for service classification can be based on many parameters – namely UE Capability, Billing Plans, Disaster Prone Geo-Locations, Festival/Event based Traffic Spikes. **Automation coupled with the elasticity of the cloud, is a key factor towards addressing resilience.** In the NFV architecture, an Orchestrator provides this functionality. Hence a **well-orchestrated vEPC in a NFV platform is essential to address these challenges.**

Failure Specific Redundancy and Failover management

The conventional response to address the condition of failure is that of provisioning geo-redundant servers within or across separate geo-locations based on revenue and priority. However, such an operation is costly and often leads to under-optimized resources. **The cloud provides the control for this kind of optimization, by orchestrating the resources with the help of better VNF state or failure measurement parameters at the VIM layer.** Thus costs are reduced and a better QoE is ensured across a larger section of the subscriber base.

Failure Detection and Failover Strategy

Lack of failure detect ability within a network is one of the most important factors contributing to a reduced QoE. Simulation and automation of failure conditions from call models of peak traffic are needed to be able to detect network failures. Such call models while in theory, can be easily mapped to failure conditions, are difficult to arrive at.

Traditional failure detection mechanism involve the detection of storms (areas in the network that are experiencing large amounts of potential retransmission traffic). Retransmission of packets generally suggest a network condition where a particular service or node is failing. **The best solutions for this are automation test suites good at producing scenarios or call models of failure and detecting the causes with forensic analysis tools.** The ability to determine a call model that matches real world conditions is the key for this kind of strategy. Automation and cloud modeling are the tools that need to be used to address these use cases.

MOBILITY AND RESILIENCE

Mobility is the prime use case of the vEPC. In order to test mobility, what are the functions of the EPC that are of interest? Figure 2 describes the salient use cases in the EPC network:

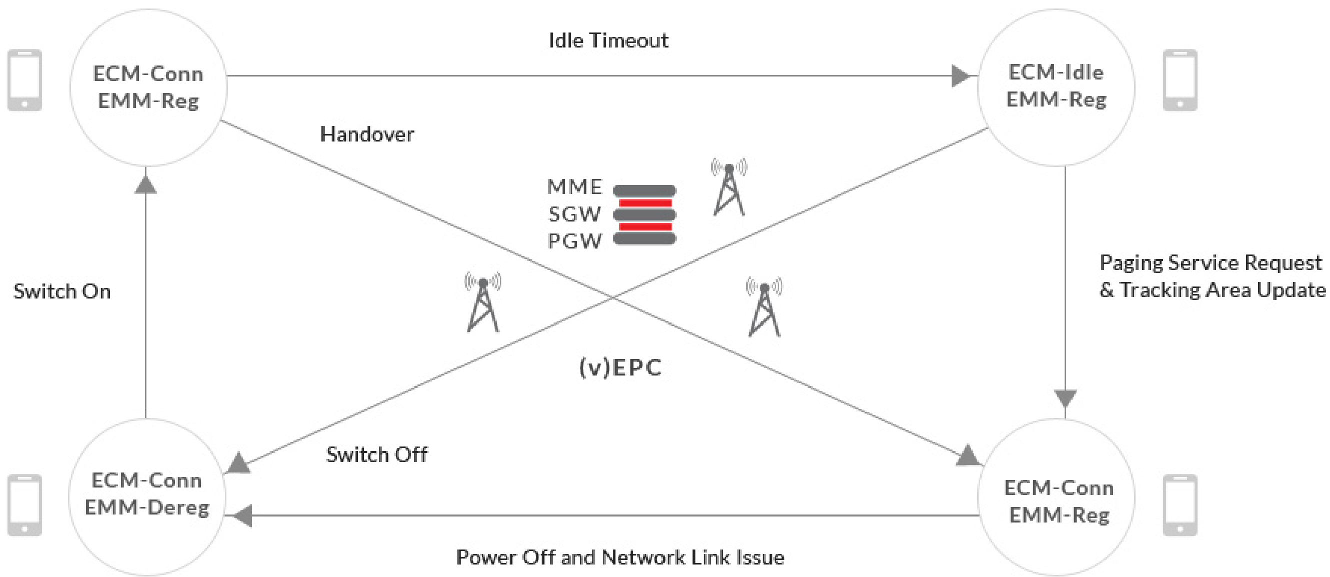

Figure 2

In Figure 2, **it is seen that the service classification and redundancy can be planned with the help of a few parameters from these use cases**. The most comprehensive way to segregate clusters in the network is by the UE Capability characteristics. Such classification can help in deciding the service clusters down to a more granular level, which is the subscriber.

Idle Mode

An example of a service clustering strategy to achieve resilience is the Idle Mode. In this particular case the capability of the UE could have many dimensions, especially with the advent of IoT. **Specific rules in the MME to reduce the signaling to different classes of UEs can make the case for a MME to be part of a particular service cluster.** Corresponding gateway and policy nodes can be aligned with this classification in order to properly segregate a network.

Testing of clusters of this nature have their place in the Telco lab. It relies on automation and orchestration in order to achieve the dynamic service clusters. The use cases related to Idle Mode Signaling need to be tested in order to arrive at conclusions about the service clusters. This aids in conceptualizing the needs for resilience and an adequate failover strategy when challenged by load scenarios. Such scenarios carried out in a bare metal environment with the lack of orchestration would lead to faulty resilience strategies. That would be very costly, and inhibit the Service Provider's ability to do dynamic services provision.

Resilience

Like Idle Mode, would it make sense to isolate other use cases for redundancy and failover strategy? The Telco lab could be used to benchmark and test different service classification strategies and their resultant impact on resilience. Resilience of different networks could be benchmarked and a resilience index for each service category formulated.

Figure 3 has the use case featured in Figure 2 classified with resilience index:

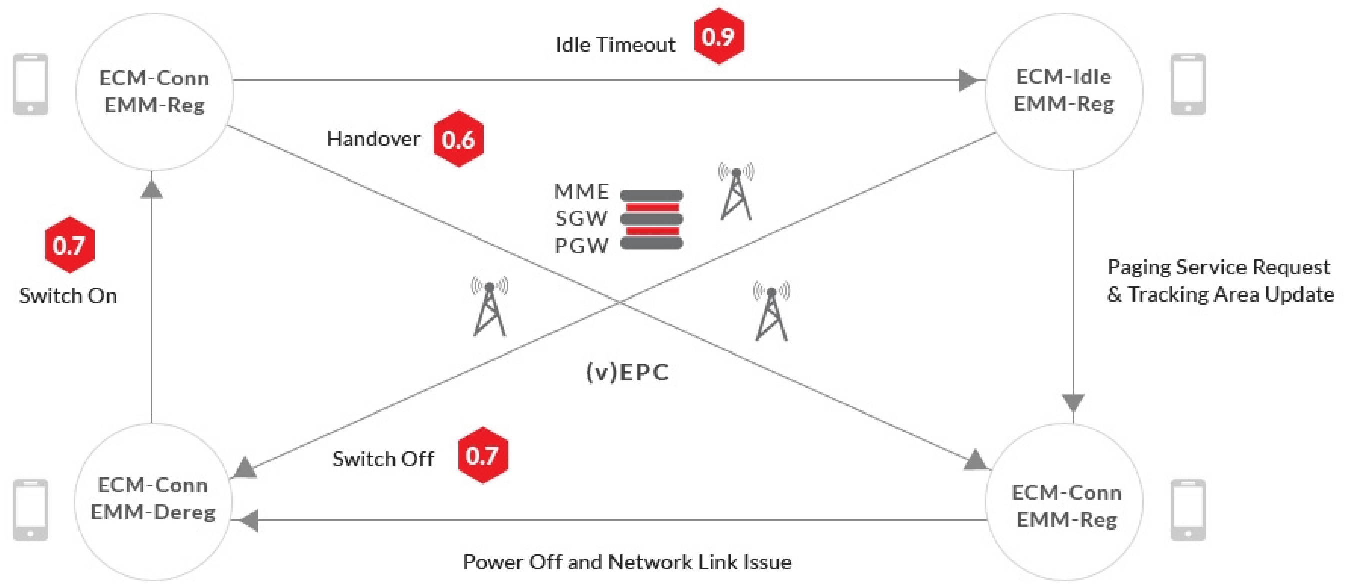

Figure 3

These resilience index values could be important when rating a network for performance based on its services.

The need for a cloud platform for this kind of benchmarking cannot be overstated. Along with a cloud platform, there is also a strong need for a benchmarking tool. A test orchestrator that is able to run tests, calculate benchmarks and indexes for the rating of a feature is essential.

OPERATIONS AND RESILIENCE

Once network services are segregated and well defined clusters formed in the network, we proceed to understand how the Operations Support Systems (OSS) in the Service Provider's network can be involved in connecting the dots. This is to optimize the vEPC deployment. The Element Management System (EMS) of the OSS is a key ingredient for this solution to work effectively. The EMS would now integrate with the VNF orchestrator, in order to make decisions based on load characteristics. The EMS would have the added capability to do fault correlation and root cause analysis. This is in order to send notifications understandable by the VNF orchestrator.

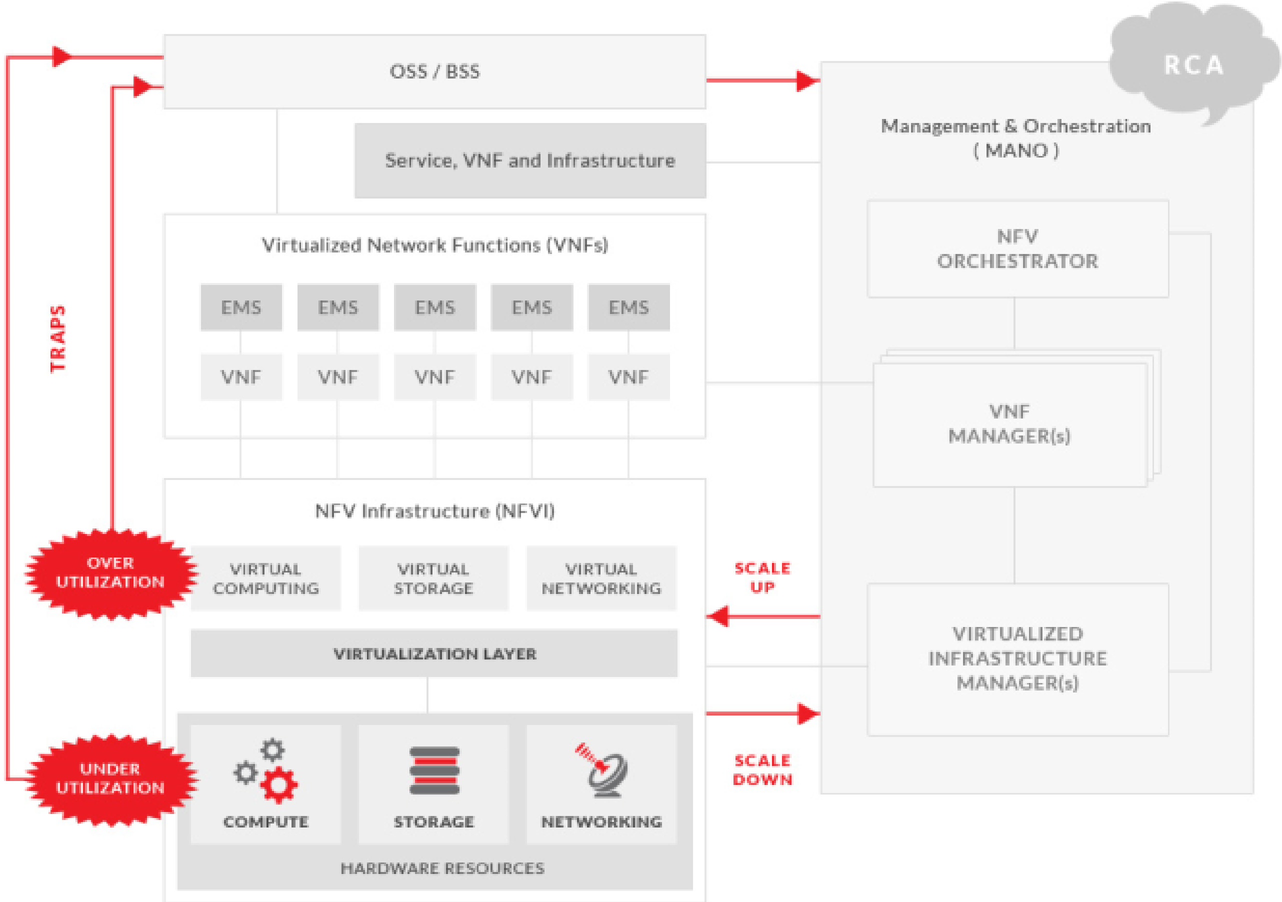

Figure 4

Figure 4 depicts the scenario in question. The vEMS in a NFV ecosystem along with an Orchestrator needs to be tested thoroughly in the lab before being put into production. A test orchestrator that can validate load situations in a service clustered network would be ideal. This gives reference parameters to fall back upon, when challenged by failure due to load. Moreover, these scenarios needs be executed again during deployment and field trials before "going live".

TEST ORCHESTRATION

Test Orchestration is essential for validation of network services, performance and evaluation of the network under extreme stress. Test Orchestration helps to generate benchmark characteristics of a particular network when subjected to different scenarios. Scenarios represents different Call flows, load conditions, etc. and acts as templates for feature testing. These feature test files can be augmented over a period of time by stake holders responsible for the network. Network capability and functionality can be documented with the help of these feature testing files. These can also serve as a chronological record of the network, as it evolves to adhere to newer specifications and features.

Behavior Driven Development

Behavior Driven Development (BDD), when used to represent the scenarios of Test Orchestration tool gives a new dimension. It assists in easy understanding of the network through the feature test files and benchmarking numbers.

What is BDD? BDD refers to the definition of test cases which are closely associated with the actual specification or requirements of the evolving network. The BDD approach makes use of a high level Domain Specific Language (DSL) to define the feature test files (more commonly known as feature files). The feature files serve as reference for the original requirement as detailed in a standards body specification. In the case of vEPC, we're referring to the 3GPP specifications. Below is an example of a feature file that verifies the capability to do a UE Attach with load characteristics.

This example feature file is explained with its various sections:

BDD : example feature file

(Feature Name or brief description of feature to test)
```
Feature: S1AP Initial UE Attach
```
(Tags that can be used to reference the test case)
```
@initial-attach
```
(The scenario depicting a detailed description of the test case)
```
Scenario: Initial Attach with IMSI
```
(The definition of the test case begins here onwards)
```
Given the test data is in file /featureFiles/MESSAGE_BUNDLES/S1AP_MESSAGES.xml
```
(Steps to bring test setup to initial state after execution of test case)
```
Given the steps below will be executed at the end
When I run the SSH command "sudo service mme_gw restart" on node MME
Then the ending steps are complete
```
(Connect to all relevant endpoints of the test case)
```
Given all configured endpoints for S1AP are connected successfully
```
[KPI Measurement Grammar defining load characteristics]

(Optional load scenario begin statement with switch to turn on and off)
```
Given I setup load scenario with the following parameters:
  | parameter              | value          |
  | switch                 | off            |
  | call_model             | initial-attach |
  | num_subscribers        | 10             |
  | load_percentage_factor | 100            |
```
[Functional Grammar defining packet send from node]

(Send an S1AP message over S1-MME interface)
```
When I send S1AP message S1_SETUP_REQUEST on interface S1-MME with the following details
from node eNodeB1:
  | parameter                                              |           value |
  | global_enb_id.mcc                                      |             208 |
  | global_enb_id.mnc                                      |              93 |
  | global_enb_id.macro_enb_id                             |            3584 |
  | enb_name                                               | eNB_Eurecom_LTEBox |
  | supported_tas_list.0.tac                               |               1 |
  | supported_tas_list.0.broadcast_plmns.0.plmn_identity.mcc |           208 |
  | supported_tas_list.0.broadcast_plmns.0.plmn_identity.mnc |            93 |
  | paging_drx                                             |             128 |
```
[Functional Grammar defining packet received at node]

(Receive an S1AP message over S1-MME interface)
```
Then I receive and validate S1AP message S1_SETUP_RESPONSE on interface S1-MME with the
following details on node eNodeB1:
  | parameter                                          | value |
  | served_gummeis_list.0.served_plmns.0.plmn_identity.mcc |  208 |
  | served_gummeis_list.0.served_plmns.0.plmn_identity.mnc |   93 |
  | served_gummeis_list.0.served_group_ids.0.mme_group_id  |    4 |
  | served_gummeis_list.0.served_mmecs.0.mme_code          |    1 |
  | relative_mme_capacity                                  |   10 |
```
…………

………. .

(Intermediate S1AP SEND/RECEIVE messages over S1-MME interface not shown for simplicity)

…………….

…………. .

[KPI Measurement Grammar marking end of load characteristics]

(Optional load scenario ending grammar statement)
```
Then I finish load scenario within 2 Minutes with the following parameters and wait to
generate report:
  | parameter  | value          |
  | call_model | initial-attach |
```

Organizational Aspects of Testing

There are various aspects to testing apart from the technical angle. **One key aspect of test orchestration is to bring each department of an organization with separate and often disparate policies to the same table.** From the point of view of the vEPC, there are three very distinct functional units called the eNodeB, MME and S/PGW. Each of these functional units have different functional and performance testing requirements. If classified as departments within an organization, each prefer independent schedules to achieve their targets. However, they have a single release schedule which is dictated by the proper functional and performance characteristics of the end product – the vEPC. BDD has been acknowledged to be the solution to this organizational dysfunction that can arise when specifications and processes are not properly followed. **BDD enforces the requirements that the different entities in the organization need to follow with the help of mutually agreed-upon feature files.**

CONCLUSION

The vEPC use case pertains to mainly two areas from a value addition perspective of its precursors. These are - **load management and resilience from failure. Test orchestration tools are essential to** reach an understanding about the quality of the services being offered by the network. This helps **determine benchmark characteristics in heterogeneous multi-vendor network environments.**

There are few tools or frameworks that adapt rapidly to the changing needs of network solution testing by incorporating the concepts of BDD, network protocol emulation, and the network use cases. **ABot is one such tool that incorporates all the above and stands out as a network test orchestration solution.**