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Applying Virtualized Evolved Packet Core in Palestinian Mobile Operators

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الاهداء

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ثم أتوجه بالشكر إلى من رعاني طالبا في برنامج الماجستير، ومعدا هذا البحث المشرفان الفاضلان الأستاذ الدكتور: سعد طربية والدكتور شادي عطاالله، اللذان لهم الفضل- بعد الله تعالى- على البحث والباحث مذ كان الموضوع عنوانا وفكرة إلى أن صار رسالة وبحثا. فلهم مني الشكر كله والتقدير والعرفان.

وكذلك نشكر كل من ساعد على إتمام هذا البحث وقدم لنا العون ومد لنا يد المساعدة وزودنا بالمعلومات اللازمة لإتمام هذا البحث ونخص بالذكر الأستاذ نعيم الحوساني.

وأتقدم بشكري الجزيل في هذا اليوم إلى أساتذتي الموقرين في لجنة المناقشة رئاسة وأعضاء لتفضلهم علي بقبول مناقشة هذه الرسالة، فهم أهل لسد خللها وتقويم معوجها وتهذيب نتوآتها والإبانة عن مواطن القصور فيها، سائلا الله الكريم أن يثيبهم عني خيرا.

الاقرار

أنا الموقع أدناه، مقدّم الرسالة التي تحمل العنوان:

Applying Virtualized Evolved Packet Core in Palestinian Mobile Operators

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Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

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List of Abbreviations

1G	First Generation
2.5G	Represent GPRS
3.5G	High Speed Packet Access (HSPA)
3G	Third Generation
3GPP	3rd Generation Partnership Project
4G	Fourth Generation
5G	Fifth Generation
5G	Fifth Generation
AAA	Authentication, Authorization, and Accounting
API	Application Programming Interface
APN	Access Point Name
B2B	Business to Business
B2C	Business to consumer
CapEx	Capital Expenditures
CDN	Content delivery network
CPEs	Customer premises equipment
CTO	Chief Technology Officer
DC-HSPA	Dual Carrier-High Speed Packet Access,
DPI	Data Packet inspection within PS core
DR	Disaster Recovery
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortization
eNB	Evolved Node B
eNodeBs	Element of an LTE Radio Access Network
EPC	Evolved Packet Core
EVO BSC	Evolution Base Station Controller
FTTH	Fiber to the Home
GB	Gigabyte
GDP	Gross domestic product
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Services
GW	Gateway
HLR	Home Location Register
HSS	Home Subscriber Server
HW	Hardware
IaaS	Infrastructure as a service
ICT	Information and communication technology
IMS	IP Multimedia Subsystem
IoT	Internet of Things

IP	Internet Protocol
IPS	intrusion prevention system
IT	Information Technology
KPI	Key Performance Indicator
LTE	Long-Term Evolution
M2M	Machine to Machin
Mbps	Megabits
MENA	Middle East and North Africa
MGW	Media Gateway
MKT	Market
MME	Mobility Management Entity
MSC	Mobile Switching Centre
NaaS	Network as a service
NFV	Network Function Virtualization
NFVI	Network Function Virtualization Infrastructure
OpEx	Operating Expenses
OSS	Operations Support System
OTT	Over the Top
PaaS	Platform as a service
PCRF	Policy and Charging Rules Function
PDN	Private Data Network
PGW	Packet Gateway
PS	Packet Switch
Q2	Second Quarter of the year
Q4	Furth Quarter of the year
QoS	Quality of Service
R&D	Research and development
RAN	Radio Access Network
RFID	Radio-frequency identification
S1-MME	Interface for the control plane protocol between E-UTRAN and MME0
S1-U	Interface between E-UTRAN & Serving GW
S5	Interface is used between an S-GW and P-GW located within the same administrative domain (non-roaming)
SaaS	Software as a service
SAE	System Architecture Evolution
SDN	Software Defined Network
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SLA	Service-Level Agreement
SMS	Short Message Service

SO Strategies	Strengths Opportunities Strategies
SOWT	Strengths Opportunities Weakness Threats
ST Strategies	Strengths Threats Strategies
SW	Software
UE	User Equipment
vEPC	Virtualized Evolved Packet Core
VM	Virtual Machines
VNF	Virtual Network Function
VNFaaS	Virtual Network Function as a Service
VNPaaS	Virtual Network Platform as a Service
VNSaaS	Virtual Network Software as a Service
VPN	Virtual Private Network
Wi-Fi	Wireless fidelity
WLAN	Wireless local area network
WO	Weakness Opportunities Strategies
WT	Weakness Threats Strategies

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Abstract

Palestine is a developing country suffers from occupation and its obstacles in different domains. Telecom industry is one of the fields that struggles from existing regulation which forced by occupation. In addition to global declining in telecom sector profit despite increasing in data demand. Thus, telecom operators had to find solution that overcome profit declining at the same time to handle increment of data traffic with minimal cost. Network Function Virtualization (NFV) is one of the technologies that proposed to minimize the effect of profit decline and traffic increment.

NFV technology is new trend to get over the infrastructure challenges in introducing new services and managing the rapid growth in the data services demand. The main goal of this study is to differentiate between service models: Network Function Virtualization Infrastructure as a Service (NFVIaaS), Virtualized Network Software as a Service (VNSaaS), Virtualized Network Platform as a Service (VNPaaS), and on-primes models (owned NFV, legacy system) by assessing models aspects (operational, management and commercial), and provide comprehensive recommendations for the case study in terms of the best model to deploy in the network and other specific NFV case considerations.

A module was developed with stages of assessments that ends up with the recommended Evolved Packet Core (EPC) model that can be applied in the operator based on operators' case drivers, the first one is operator readiness stage that gives an indication of operator readiness level to transform toward virtualized EPC. The second stage is Key Performance Indicators (KPIs) weight assessment that subject to business, technical, and transformation perspectives. However, KPIs weight will differ from operator to another according to their priorities and business objectives. The final stage is models rating engine for each KPI, this engine contains two main parts: the first one is qualitative KPIs rate, as models were rated for each KPI based on studies, expert's experience and vendor's feedback. The second rate part is quantitative KPIs related to investment and operational expenses for each model, however, the quantitative will differ among operators based on their cost drivers.

At the end of applying the module on a case study, the first outcome is to conclude about company readiness to transform to NFV, as its depend totally on operator judge whether to proceed in virtualization strategy or not and define the related risk of this strategy. The second outcome is to define the recommended model for EPC transformation based on KPIs weight and cost drivers.

Ooredoo Palestine is a Palestinian mobile network operator. Which operating in very challenging markets with strong competition between Palestinian services providers, in addition to illegal competition came from other operators such as Cellcom Israel, and Orange Israel.

The module was applied on Ooredoo Palestine case to get the most recommended EPC model. The results showed that Ooredoo Palestine has high readiness level to transform toward virtualization, and the recommended EPC model for Ooredoo Palestine is the owned NFV model. Further, the study showed the risk assessment and residual risk assessment of virtualization transformation related to Ooredoo Palestine case.

In general virtualization is a key strategy applied on core network to reduce the impact of telecom profit declining, the study focused on applying virtualization on packet core network for Ooredoo Palestine as this strategy could reduce the impact of challenges that face Palestinian operators

Chapter One
Introduction

1.1 Overview

The demand on data services grows very fast. However, Boniecki et al. (2016) clarified even with rapid growth in data services demand, the mobile operator revenue growth struggles, as well as the nets profit margin and Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA) margin are declining, as traditional services are under pressure and mobile operators have significant investment commitments as they are deploying mobile broadband networks to handle the huge traffic demand increment. The decline of profit margin and business continuity investment obligations, forced the mobile operator to search out for new solutions to enhance the operational cost and secure the needed network capabilities to fulfill the service demand. Network Function Virtualization (NFV) and Software Defined Networking (SDN) stand as one of these solutions to handle the data demand with cost effective approach, that optimizes and enhances operational cost, capital expenditures cost, and profit margin. This Thesis studying NFV service and on-primes models. In addition to find out the best service or on-primes that can be applied for Ooredoo mobile operator at Palestine. The importance of this study comes from two main points represented in that virtualization is new trend raised as a solution that can reduce the impact of many threats face telecom sector which will be clarified later in literature review. However, this study clarifies the use cases of virtualization strategy in emerging market and the

impact of this strategy on commercial, operational and management aspects based on virtualization and SDN experts who discussed Evolved Packet Core (EPC) (virtualized and legacy models) in many structured interviews in addition to previous experience for virtualization and SDN technologies to decide the possibility of applying virtualization on EPC system which leads to decide which business model is the best to be applied on . The second importance of this study comes from that operators can benefit from this study and reflect its results on their situation to find out best fit EPC model related to its conditions, for Palestinian operators the study shows an opportunity to reduce the impact of occupation regulations as it will be shown later.

1.2 Research Problem

The global telecom sector is under pressure of being a low profit business. As the telecom operator's profit Margins are declining. Thus, the mobile operators enforced to search out for any applicable solution to optimize and manage cost efficiently. Mobile operators today provide Mobile broadband services over Third Generation (3G) and Long Term Evolution (LTE) networks using a legacy mobile packet core architecture known as the Evolved Packet Core (EPC). The EPC has been deployed by utilizing physical various functions components which will be explained later in literature review chapter. Further, the remarkable penetration of smartphones, tablets, laptops, data demanded applications, and Machine to Machine (M2M) devices, leads to significant growth on data services consumption, this demand comes to be a real challenge for mobile

operators who have low profit margin. In emerging market, the tough competition and low Gross Domestic Product (GDP) rates result out that the customer base expects to pay significantly lower prices regardless the real cost of services. All these facts are forcing mobile operators to find better cost effective solution to handle the demand properly and enhance the profit margin or at least to maintain it at acceptable levels.

The mobile operators at Palestine are operating in very challenging markets with strong competition between Palestinian services providers, in addition to illegal competition came from other operators such as Cellcom Israel, and Orange Israel. Moreover, Palestinian people are internet educated users with high penetration of smartphones expected to reach more than 50%after introducing 3G benchmarked with Jordan market according to Bader (2011), and they were being wait very long time to have mobile broadband services network, thus by introducing the 3G services, a huge mobile data services demand are expected along with introducing new mobile data services such as M2M, this demand shall be addressed with effective solution balancing, the quality of services and cost of service.

Additional constraints are related to Palestinian market situation shall be considered in defining the best solution to handle the 3G forecasted demand efficiently, such as the supply chain complexity due to Israeli control on importing telecom Hardware (HW) from outside that makes the expansion and scalability using legacy packet core are very hard and with potential of high delay that impacting negatively the quality of service and might delay or prevent from introducing new revenue stream services that

demanded by market. However, this kind of supply chain complexity and customs control restrictions are applied on other countries and markets.

In order to assess these challenges, this research will study the best practices for transforming from Legacy EPC to virtualized Packet Core (vEPC) of NFV, focusing on Virtualized EPC (vEPC) aiming to find out the most applicable model to optimize network costs while improving or at least maintaining the same performance. In addition to support new open ecosystem to introduce new innovative revenue steam services in the market. Further, as Palestinian operators are applying 3G services, they have to make sure that any investments have been planned today are supporting the future transformation toward the Fourth Generation (4G) and Fifth Generation (5G) networks.

1.3 Research Questions

This research aims mainly to answer the following questions

1. What are the EPC NFV business models and its use cases in the emerging market?

2. What are the suitable management models to transform the legacy evolved packet core network to NFV at emerging markets?

3. How NFV will contribute in resources optimization and its impact on the company overall performance operationally and commercially?

4. What the considerations that shall be taken in account in deploying Virtualized EPC commercially?

1.4 Research Objectives

The main objectives of this study are as follows:

1. Study different EPC NFV models to deploy evolved packet core at emerging market.

2. Find out the best business model to deploy virtualized evolved packet core in mobile operators at emerging markets.

3. Define the briars and limitations of deploying NFV.

4. Assess NFV operational and commercial impact.

1.5 Structure of Thesis

The research covers the following chapters:

1. Chapter one contains a description for research problem, research main questions and main objectives.

2. Chapter two shows new technology trends, also studies related to virtualization and its impact in addition static studies shows telecom sector trends around world

3. Chapter three describes the methodology that was followed in this research to achieve objectives and goals of research.

4. Chapter four describes case study of research which is Ooredoo Palestine and existing situation in addition to problems that is related to research also SOWT analysis for case study.

5. Chapter five describes all business models related to EPC with their definitions and use cases, specifications, and pros and cons which contains cloud deployment models and on primes models.

6. Chapter six clarifies all key performance indicators (KPIs) that will be used to compare between EPC models. these KPIs almost covers operation , commercial and management sides to ensure choosing best fit EPC model according to these defined KPIs.

7. Chapter seven contains research analysis which depend on developed mathematical model can be used by any operator to choose best fit EPC model , in this research the mathematical model was applied in Ooredoo case to get the best result for EPC model. The research analysis clarify the readiness of Ooredoo Palestine to move toward virtualization, also weight of KPIs related to Ooredoo Palestine (in terms of management, operation and business transformation trigger perspectives), also the EPC models rate for each KPI.

8. Chapter eight contains the result was gotten from mathematical model related to Ooredoo Palestine case which represented in the most fit EPC that can be applied to the case.

9. Chapter nine contains conclusion of research and recommendations, risk analysis and residual risk assessment which give operator main outlines to transform EPC system.

Chapter Two
Literature Review

2.1 Literature Review

Telecom industry started in the beginning to connect people, nowadays, it is to connect people and things. The majority of connection was legacy services (voice, Short Message Service (SMS)), but after evaluation in telecom industry, the game changed and data services appear to connect the unconnected. This section summarizes the current legacy EPC challenges of handling the rapid increase in data demand and new services, and gives a brief about NFV and SDN related studies.

2.2 Data Demand

The data demand is growing fast according to GSMA (2017a), the penetration of unique mobile subscribers will increase from 65% in 2016 to reach 73% by 2020, while the total SIM connections is expected to jump from 100% in 2016 to 112% by 2020, out of this the number of mobile broadband connections have potential to reach 73% by 2020 from 55% in 2016. Reference to GSMA (2017b), the mobile subscriber's penetration is below global average, and it is expected to grow from 63% in 2016 to reach 65% in 2020. Based on GSMA (2017b), Figure 1 among years shows the forecasted MENA and Figure 2 shows global penetration out of population.

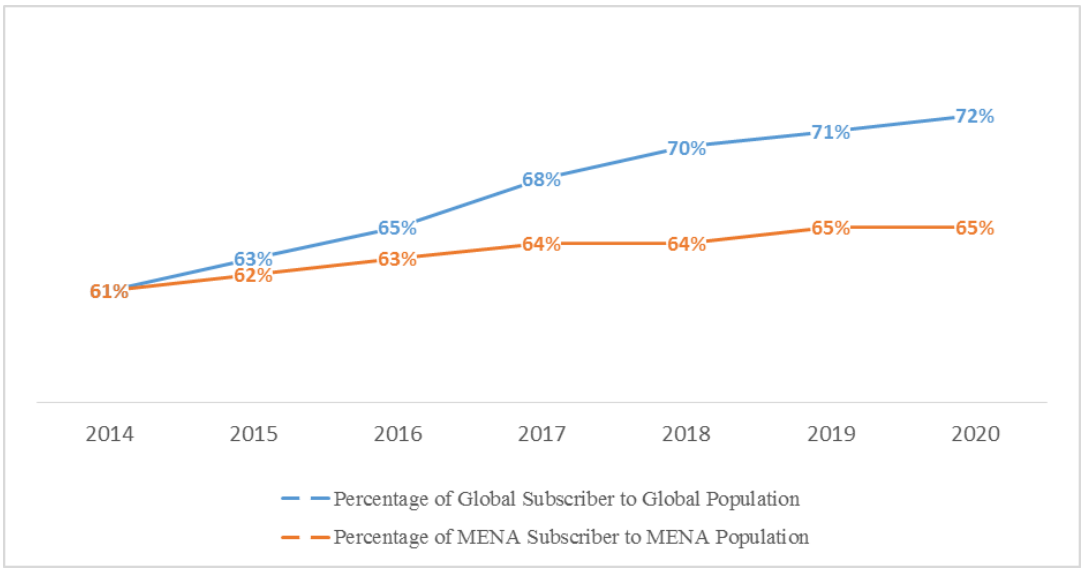


Figure 1. Forecasted MENA and Global Penetration out of population.

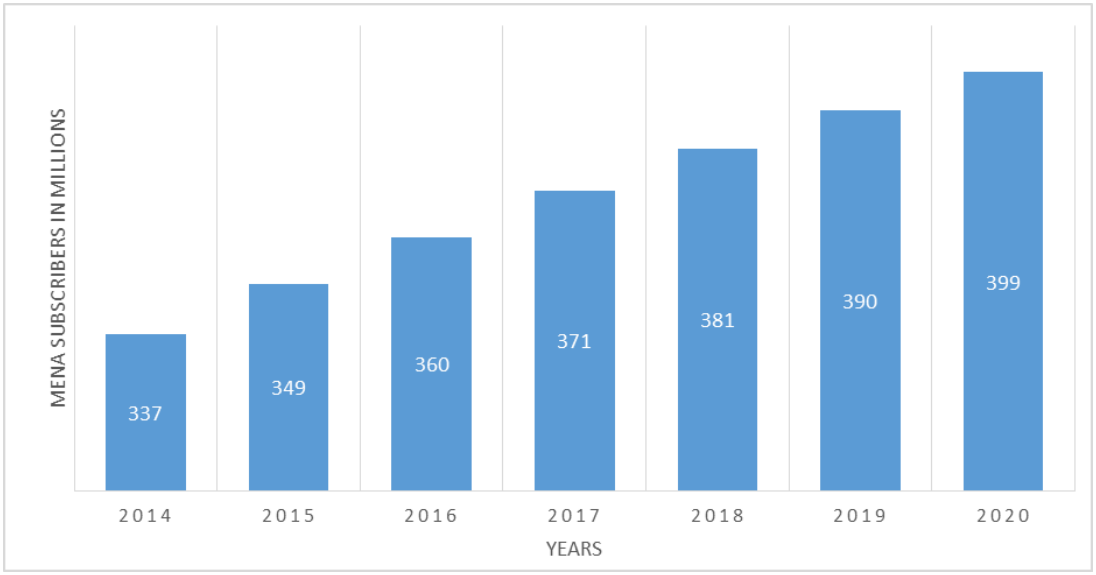


Figure 2. Unique subscribers in MENA in millions.

As GSMA (2017b) report, Figure 3 illustrates the unique subscriber penetration at level of sub – regions from Middle East and North Africa (MENA) region as Second Quarter (2Q) 2017, the other Arab states that represent (Comoros, Djibouti, Iraq, Jordan, Lebanon, Palestine, Somalia, Sudan, Syria and Yemen) has the lowest mobile subscriber penetration of 46% which is below the MENA average and global average.

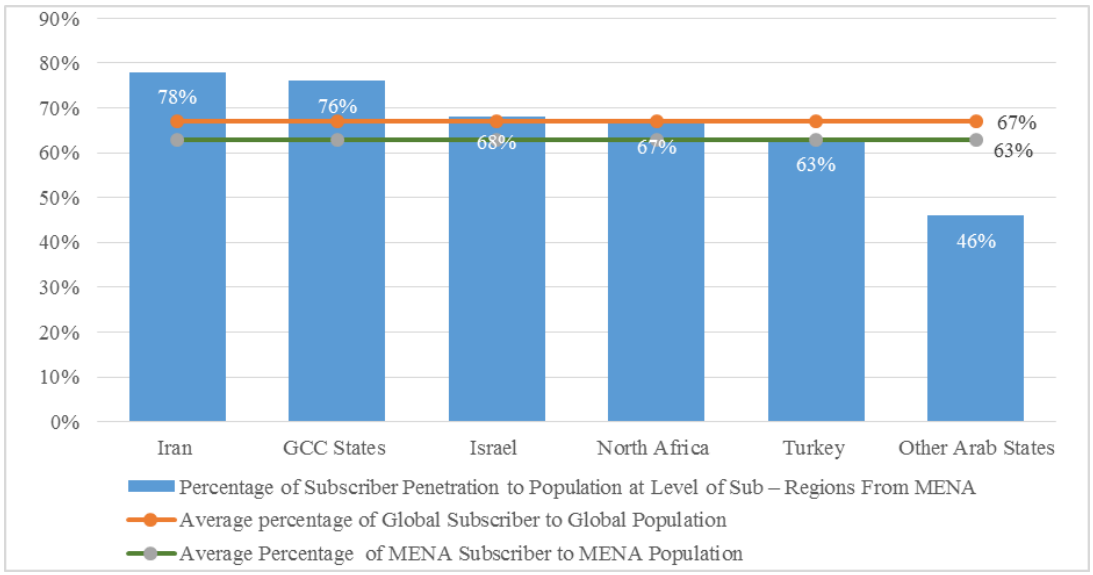


Figure 3. MENA subscriber penetration by sub-region, Q2 2017.

The subscribers in MENA region are continuing to migrate to mobile broadband services, thus, GSMA (2017b), showed that by end of the Furth Quarter (Q4) 2018 the 3G was expected to be the dominant technology as shown in Figure 4.

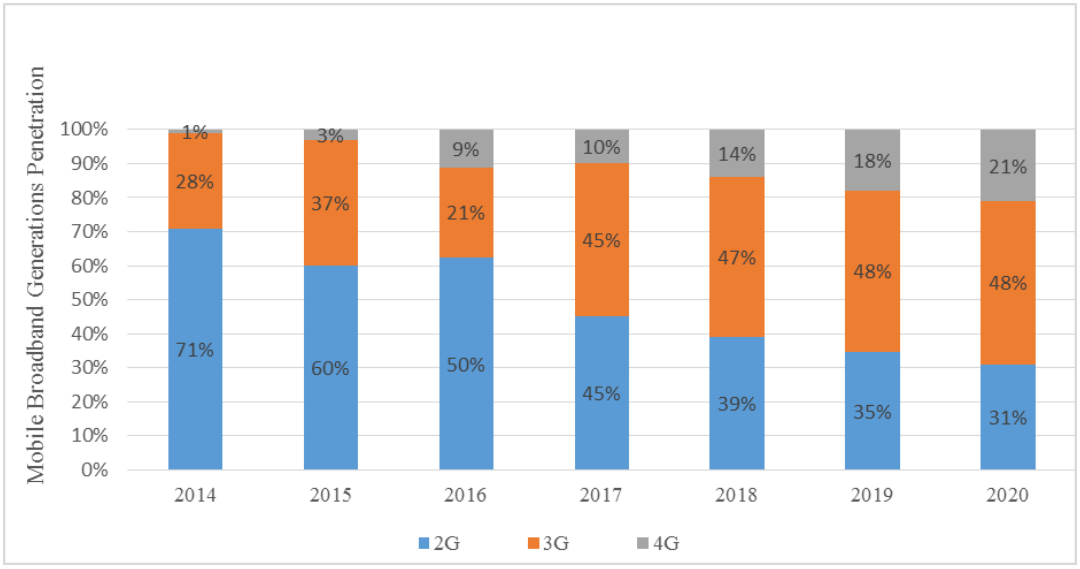


Figure 4. Technology migration in MENA Percentage of broadband connections.

Reference to COMCEC (2016) report, monthly universal data traffic in 2016 extended to reach 88.7 billion gigabytes which reflects the annual rate growth of 30% in the previous five years. Accordingly this will lead to significant growth in the universal data traffic by 47% from 2016 to 2020. Thus it is expected to reach 194 billion gigabytes.

Based on this exponential traffic progress, Internet traffic will raise in MENA (27% compound annual growth rate) reaching 10.9 billion gigabytes monthly which leads to rise the data usage average by each unique mobile subscriber from 1 Gigabyte (GB) in 2016 to around 12 GB by 2022.

2.3 Data Services

The revolution on data services such as video services, Internet of Things, big data, and Over The Top (OTT) leads to exponential growth on data demand that requires another revolution at mobile broadband technology side to fulfill continuing data growth.

2.3.1 Video Service

Based on COMCEC (2017), nowadays, video services have the major portion of the data demand in Forth Generation (4G) and Fiber to The Home (FTTH) networks. Youtube traffic dominate the high share of video traffic beside video on demand platforms and rental services such as Netflix, and Facebook streaming. The video services demand shows high potential increase due to massive events such as festivals. A stable high

bandwidth session for quite a lot of minutes, good packet throughput, accepted packet loss rate, and minimal jitter are required to maintain video quality service.

2.3.2 IoT (Internet of Things)

As Omnes et al. (2015), has defined Internet of Things (IoT) is an innovative model where a huge number of things/objects connected through one or different networks to each other, it is about connected physical elements networking with each other to support or enable new services include but not limited to machine-to-machine (M2M) and person to-computer communications (P2C). IoT devices cover a lot of domains such as utility metering, home automation, automobiles, health monitoring devices, surveillance systems and public safety systems with new smart devices and applications being created. As it promises to monitor all working conditions through IoT devices of different engineering and functional structures and optimize it accordingly. By 2025 the IoT nodes are expected to connect most of the items, most of them are necessary in our life.

2.3.3 Big Data

According to Amin and Feizi (2014), big data is a functional term used to express situation where data volume, velocity and variety exceed an organization’s capacity to storage or analyze for precise and on time decisions. Big Data every moment is generated since the beginning of data communication. Big Data is produced from all digital events, social media,

machine-to machine interactions, metering events, and call detail records. While environmental sensing, Radio Frequency Identification (RFID) systems, sensors and mobile devices transmit it. All these types of data grow very fast due to increase on its application demand. However, most of these raw data are in an unstructured form semi structured from social media events. The unstructured need a complex algorithms and computing efforts using special servers to enhance extracting the valuable information by filtering through the Big Data's noise that came from the massive volume, variety, and velocity. As the goal of algorithms to put an unstructured data into structured tables with rows and columns, in order to extract insights from this massive data. Thus, in Big Data projects often rely on data science and machine learning to overcome the challenges that can be addressed in five dimensions include the volume of data, the second is data flow velocity in all ways, the variety of data types and sources increment characterize the third one, data seems to be unstable so verifiability of data with sundered peak represent the fourth challenge, these four challenges lead to the fifth which is complexity in data processing.

2.3.4 OTT (Over the Top)

As Boubendir et al. (2015), mentioned that OTT service made dramatic jump in internet multimedia traffic, and it is expected to keep rise as it will reach 75% from total traffic. OTT can be defined as “a service, content, or an application (e.g., Skype, YouTube and Facebook ...etc.) that is delivered

to the users over the open Internet.” the definition, means that everything delivered through open Internet considered an OTT service.

Even though of Rapid development of the telecommunication system, the OTT services stand in for outmoded services, and service providers has a challenge to migrate to next level of modernized OTT services for better utilization and monetization for these communication channels.

However, legacy OTT applications are armed by cloud capabilities which current network architectures are unable to support. The challenge is to handle and adopt with dynamicity of OTT application services with a static nature of network architectures, which requires a mobile operator to transform the network to a level of more flexibility to manage the unexpected OTT user’s behavior.

2.4 Mobile Broadband Networks

This rapid demand on data services and the appearance of new innovative data applications has accelerated the development cycle of mobile broadband technologies to meet this growing demand. According to Majeed and Phil (2015), 3G Network is considered as a first Mobile broadband network used to carry broadband data services with throughput of 42 Mbps per cell (DC-HSPA+), but this wasn’t sufficient enough to satisfy the fast growth in data services demand that requires mobility, therefore, 4G mobile broadband network was introduced to handle data demand with higher speed up to 100 Mbps, but new innovative data applications (IoT, M2M, ..etc.,) would require both higher throughput and

low latency which is beyond the capabilities of current 4G Networks. 5G will stand to fulfill these applications requirement and the data quantum leap. As Warren and Dewar (2014), mentioned 5G promises to introduce a 'hyperconnected society' where the mobile totally changes people life. Table 1 shows the Evolution of Mobile Generations. (Warren and Dewar, 2014).

Table 1. Generation Sole Service Differentiator Weaknesses.

Generation	Sole Service	Differentiator	Weaknesses
1G	Analogue phone calls	Mobility	Poor spectral efficiency, major security issues
2G	Digital phone calls and messaging	Secure, mass adoption	Limited data rates – difficult to support demand for internet/e-mail
3G	Phone calls, messaging, data	Better internet experience	Real performance failed to match hype, failure of WAP for internet access
3.5G	Phone calls, messaging, broadband data	Broadband internet, applications	Tied to legacy, mobile specific architecture and protocols
4G	All-IP services (including voice, messaging)	Faster broadband internet, lower latency	

5G use cases are challenged to low latency and high bandwidth requirements, Figure 5 shows the potential use cases of 5G (Warren and Dewar, 2014).

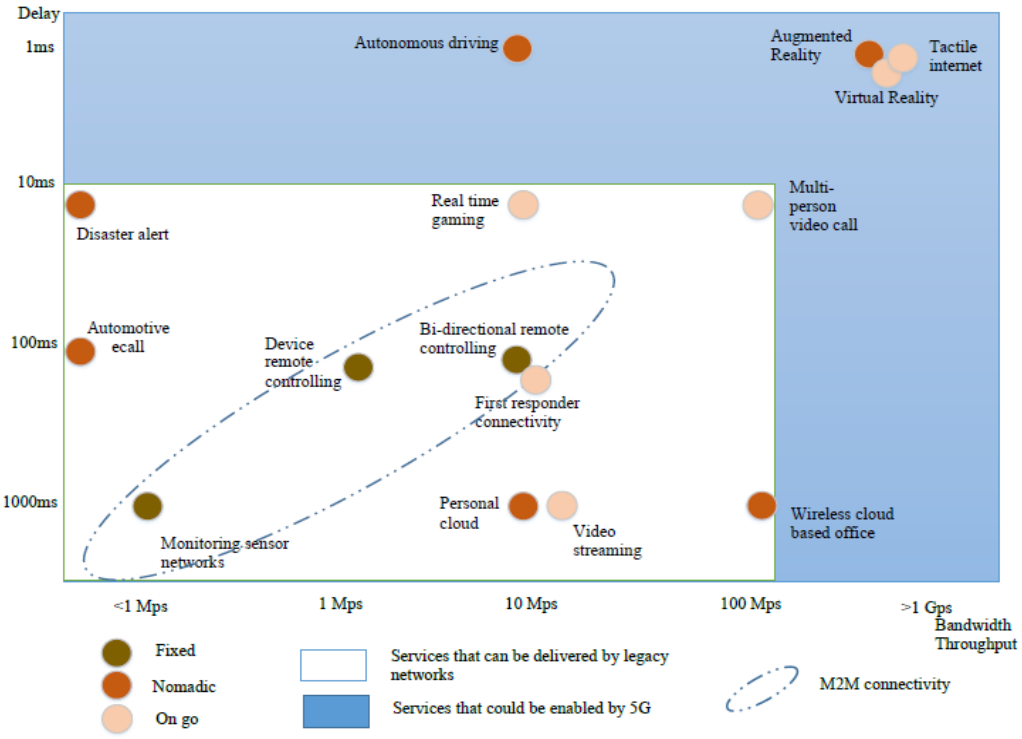


Figure 5. Bandwidth and latency requirements of potential 5G use cases.

However, to enhance end user mobile broadband experience, the mobile broadband technologies development has been focused on spectrum efficient utilization and radio access capabilities, and operators are developing 4G networks through rollout of LTE-Advanced technologies besides doing a trails for 5G networks. While network architect, the operators considered the deployment of network function virtualization (NFV), software defined networks (SDN), and heterogeneous networks (HetNets). Thus, NFV/SDN technologies will play a major role in the evolution of mobile networks and mainly in the core network evolution.

2.5 NFV/SDN Concepts

In this context, it was required to develop a new model of infrastructure that support these new services (Video Streaming , OTT, IoT) and overcome its challenges in proper modeling that take into consideration the need for resources optimization (capacity, cost, and time). Thus, the SDN and NFV concepts were developed to be the base of this change.

Based on Omnes et al. (2015) definition Software-Defined Networking (SDN) can be considered as a tool for dynamic resources control via programming network functions, with control layer functions, by using software technology and thanks to novel interfaces. Figure 6 shows Wipro (2018), solution SDN/NFV architecture for EPC.

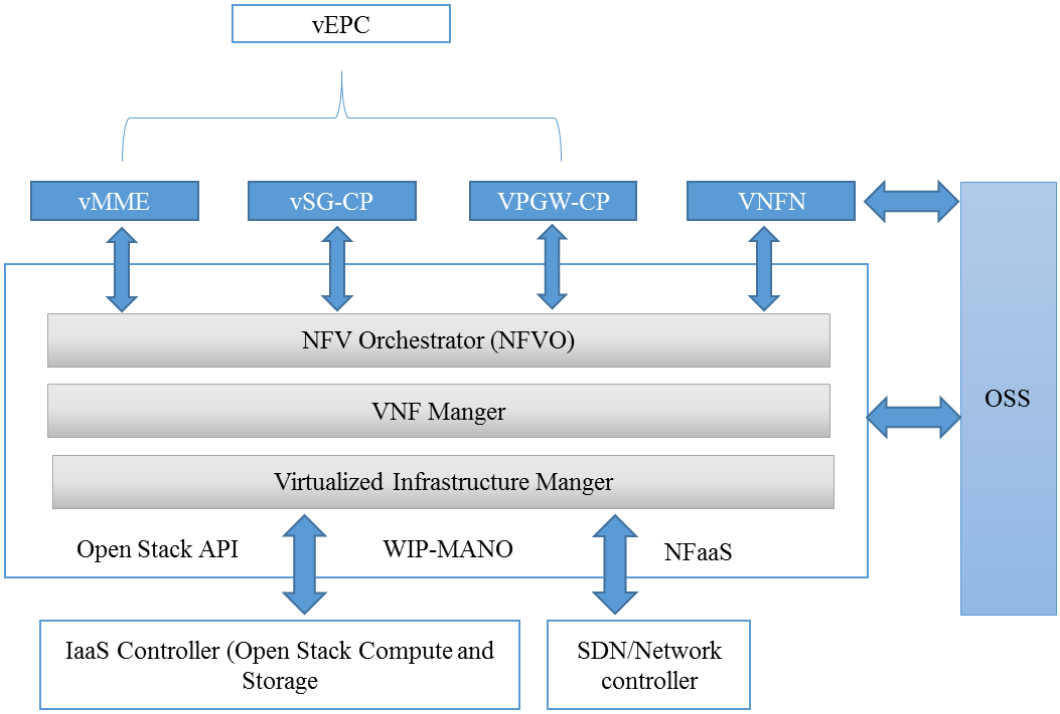


Figure 6. SDN/ NFV Wipro solution.

As ETSI (2013), defined Network Function Virtualization (NFV) as a technology aims to transform the legacy architect networks by evolving standard IT virtualization technology to consolidate many network equipment types onto industry standard high volume servers, switches and storage. Together NFV and SDN are comprehensive solutions to get over the infrastructure challenges in introducing new services and handling the rapid growth in the data services demand.

2.6 Legacy EPC Network

EPC is IP-based service provisioning for Mobile broadband network. It reduces the hierarchy between mobile network elements. As Jain et al. (2016), clarified the current legacy EPC architecture as shown in Figure 7 consists of Mobile Management Entity (MME), Serving Gateway (SGW), Packet Data Network Gateway (PGW), Policy Control Rules Function (PCRF) and Home Subscriber Server (HSS).However, based on Verizon Network Infrastructure Planning (2016), the legacy EPC has been built based on vendor special hardware and software platforms design.

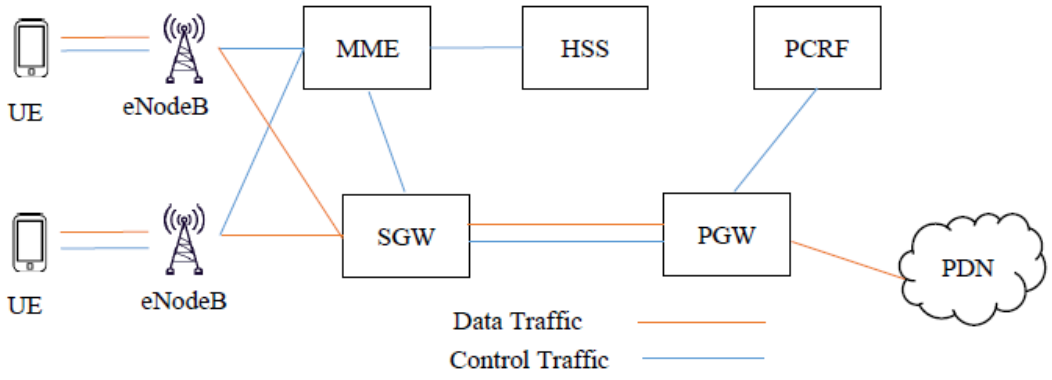


Figure 7. Legacy Evolved Packet core.

These massive network elements have serious challenges coming from long design, development, and installation phases which lead to: slower time-to-market of introducing new products and services, operation overhead and management complexity, and higher CapEx to revenue ratio in handling the market demand. According to Firmin (2016), flowing are the elements of EPC with its main functions.

2.6.1 MME (Mobility Management Entity)

The MME is answerable for of all the Control plane functions associated with user's mobility and security. Relative to security to end-user which start with authentication beside initiation and ciphering ending with integrity protection algorithms. All signaling process are managed by MME in addition to manage the tracing and paging of user equipment in idle mode. (Firmin, 2016).

2.6.2 HSS (Home Subscriber Server)

HSS is a data base includes user's information beside its management role in mobility specific in user authentication and access authorization. (Firmin, 2016).

2.6.3 PCRF (Policy and Charging Rules Function)

PCRF works in real-time to manage policy rules in networks through many strategies such as prioritize network traffic in dynamic way, managing needed information for revenue assurance and bandwidth. According to

charging resolutions it is responsible for policy control and flow. (Firmin, 2018).

2.6.4 SGW (Serving Gateway)

The SGW represent data plane which is responsible to carry IP traffic between the User Equipment (UE) and other networks. It is the interconnect point between the radio network and the evolved packet core. It is logically connected to PGW. (Firmin, 2016).

2.6.5 PGW (Packet Gateway)

PGW is the anchor point between the EPC and the external IP networks. These networks are called Packet Data Network (PDN). (Firmin, 2016).

2.7 NFV Role on EPC Transformation

The importance of EPC come from its architecture that splits the control and data planes in the mobile broadband network that provides fast network performance, and reduces the hierarchy between mobile networks elements .EPC hierarchy is shown in Figure 8 based on Penttinen (2012), architecture. However, handling huge growth in data traffic using such legacy architecture requires high investment in vendor’s special hardware in addition to high operational expenses and complexity in service delivery.

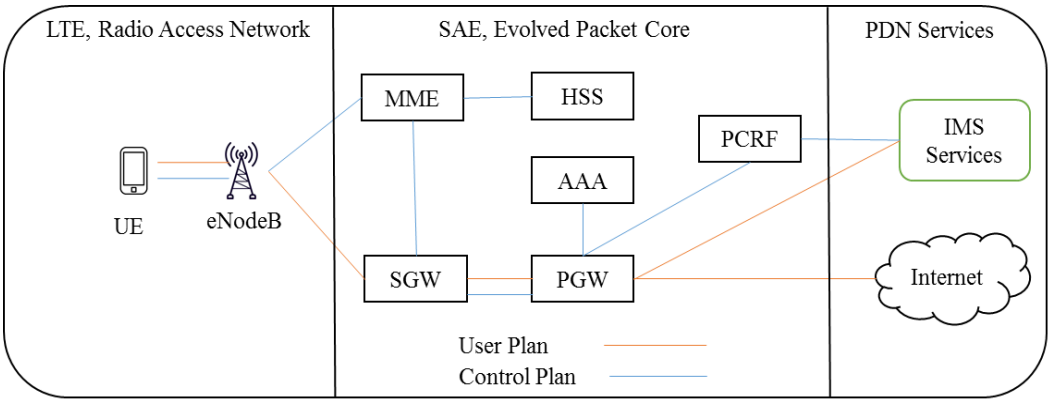


Figure 8. Evolved Packet Core (EPC).

Therefore, according to Hewlett Packard Enterprise (2017), increasing gap between capacity and demand is a significant sign for deploying new approaches and new network architects that can enable mobile operators to handle more traffic with less cost. NFV raised as a new technology provides an efficient solution which can enhance the flexibility required by mobile operators to adapt and accommodate this dynamic market demand. Figure 9 shows NFV concept.

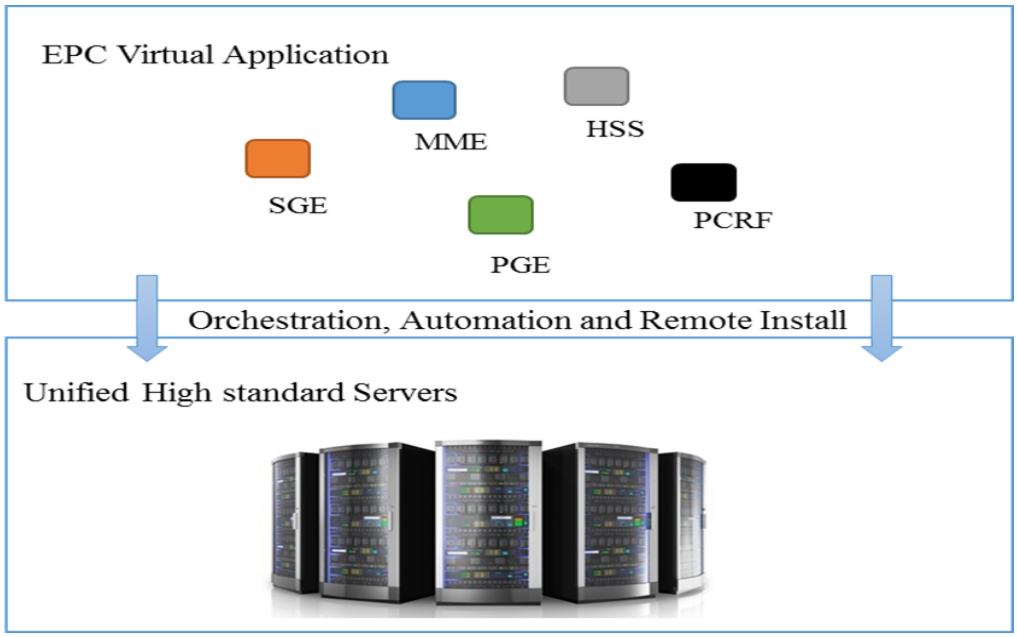


Figure 9. EPC Virtualized Network Model.

According to Telecoms (2016)**, a**n annual industry survey aimed to highlight new telecom trends and issues that affect the sector by sharing opinions of telecoms industry professional. One of these aspects was NFV, the results indicates that around 32% of these companies agreed that NFV was a priority technology investment for the company in 2016. Another important investigation that audience was asked about NFV was their approaches to NFV; 40% of all respondents clarified that they were investing about use case scenarios, 24% their trials were undertaken, 15% of them had already lunched their scenarios while 15% said that they didn't have the required resources. However, 6% showed that they uninterested in rolling out NFV, another important finding from this survey that around 45% responded indicated that the virtual EPC had the highest priority to be lunched as one of NFV use cases.

However, there are a lot of models were developed to get benefit from the NFV to support the mobile operators in handling the capacity, in this research will study the most applicable business model based on management perspective for mobile operators in Palestine market.

2.8 Business Models

According to Osterwalder et al.. (2005), business model is the umbrella that leads to the shape of business through different strategies and enterprise models, the business model is a tool to achieve the business logic and the firm objectives by managing set of objects, concepts and their relationships. Moreover, the business model defines the value provided to

customer and its financial consequences, therefore the effective business model that achieves the best value to customer with targeted financial KPIs in the organization. Figure 10 shows an example of the business model concept in an organization and its potential elements and inputs. (Osterwalder et al., 2005).

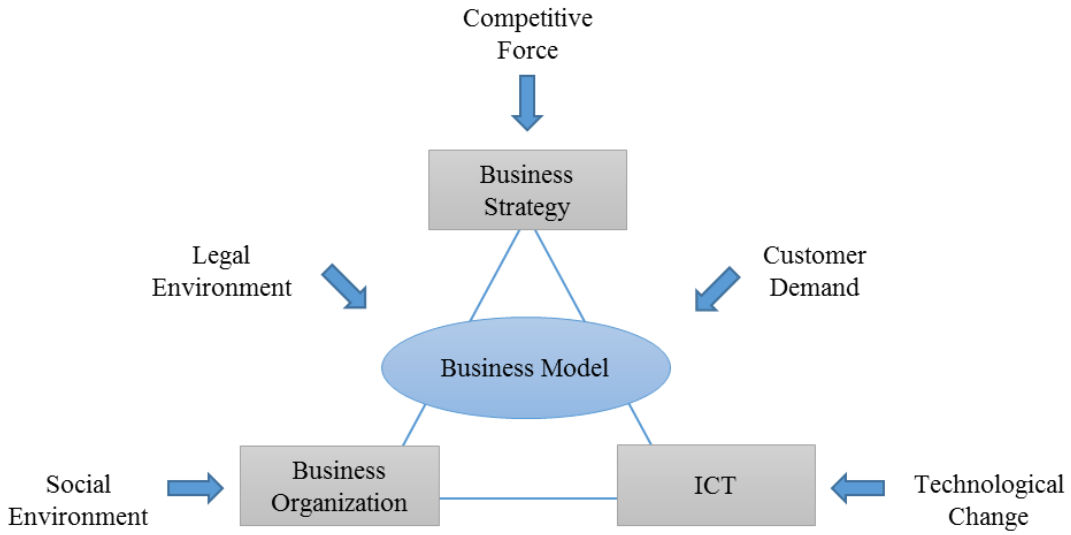


Figure 10. The business models in the firm.

2.8.1 Enterprise Model

The Enterprise model is a set of activities and processes used to manage the business in an organization. The enterprise models have different types; depend on the nature of organization business, such as operation models, deployment models …etc.

In ICT industry enterprise models have different sorts which can form the business model of organization such as deployment and service models.

2.8.2 Deployment Model

Based on OpenText (2016), deployment model is one of the important terms that represents enterprise model for Information Communication Technology (ICT) .There are many methods to define the element of the model. Thus there are no clearly descriptions or standards. So deployment models would be defined based on field of the work. For Telecom area deployment models are: on-premises, cloud, hybrid, and managed/hosted.

2.8.3 Service Model

Based on Wu at el (2017), a service model in general describes the characters of the service in a communicable approach. Service model has two main types of models which are customer service model and service delivery model, customer service model is related to define a service provided to end user by operator’s network.

A service delivery model is used by a network operator to define and manage how a service is engineered in the network. It can be used by a human operator (such as via a management station) or by a software tool to instruct network components. Such models are sometimes referred to as "network service models" and are consumed by "external systems" such as Operations Support System (OSS). A service delivery model is expressed as a core set of parameters that are common across a network type and technology: additional features that are specific to the configuration of individual vendor equipment or proprietary protocols would be defined in

extensions or augmentations of the model. Service delivery models include technology-specific modules.

Thesis focuses on cloud service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

2.9 NFV and SDN Models Review

The researchers paid attention to benefits of NFV & SDN, so many models are developed to maximize the benefits of them in deploying new services at different use cases.

There have been several proposals and designs for network components using principles of NFV, most of the researches were discussed developing new NFV architectures for mobile network and its components for better resources utilization and cost optimization taking in consideration the service and network performance aspects. Riggio et al. (2015), developed an NFV–based management and orchestration framework for WLANs networks; as well they developed a service function chain algorithm for better resources utilization. While the researchers Li and Chen (2015), highlighted the increasing the capital and operational expense of service providers in legacy networks, in addition to network complexity, the authors presented the need of moving from legacy network to NFV through analyzing a survey of different approaches of NFV, they concluded that deploying the software-defined NFV architecture with applying its application of service function chaining no more needs for middlebox, which support more flexibility in the network infrastructure, that ending

with cost & resource optimization in processing the growing demand and traffic.

On other hand, there are other studies such as ETSI (2013), which focused on developing the most effective business management models for deploying the NFV among the mobile network components. Moreover, proper model for each real use case was discussed, the management models that were discussed: Network Function Virtualized Infrastructure as a Service (NFVIaaS) where the providers offer infrastructure as a service, Virtualized Network Function as a Service (VNFaaS), this model the network functions will be provided as a service, Virtualized Network Platform as a Service (VNPaaS), this model provides platform as a service which is more flexible and scalable than VNFaaS because it provides the customer the ability to add VNF and control function .etc.). While Manthena (2015), proposed Network as a Service (NaaS) as evolutionary approach of cloud implementation strategy that support a gradual deployment scenario through a highly complementary co-existence between NFV and SDN technologies and the most major existing network technologies.

Bilal et al. (2016), analyzed a real life mobile data network, concluding that resource utilization is varying based on network scale, showing that even with large data demand and large data plan, the virtualization with dynamic scaling of node size based on load is more cost efficient. The study showed that vertical scaling with resizing the VMs is the most proper and cost

efficient approach for small scale networks of dedicated resources, rather than horizontal scaling of adding more VMs.

As 4G Americas (2014), mentioned that the separation of control and data planes enables the virtualization of the separated control plane software, so SDN can act as an enabler for NFV. However, NFV can also act as an enabler for SDN because the separation between data-plane and control-plane implementations is simplified when one or both of them are implemented in software running on top of standard hardware. Cloud computing is IP based computing services that enable new approaches of offering services such as (i.e., IaaS, PaaS and/or SaaS) to enterprises and consumers. While these technology trends can be merged to offer new model such as NFVIaaS, VNPaaS, and Content Delivery Network (CDN) cloud which is merging the concept of NFV and cloud services. This research sheds the light on the business models of NFV rather than the technical topology of the NFV network.

2.10 Related Work

Mobile operators paid more efforts in piloting and deploying NFV use cases to overcome the declining in telecom services profits, Mobile operators are counting on NFV use cases to play major role to reduce the optimize their service’s cost, at same time they aiming to maintain the quality of service or enhance it as much as possible, in addition to introduce new services and comply with services trend with cost efficient network using NFV. This section sheds the light on related researches that

discussed and analyzed the NFV role within mobile operators and its impacts on services KPIs, financial KPIs (CapEx/OpEx/EBITDA), and the value proposition of introducing new services.

Virag et al. (2016), discussed the main strategic options that Mobile operators has to think about to reconfigure its value. One of these options is the network virtualization concepts (Cloud, NFV, SDN), the research addressed the value of applying virtualization concepts on core network architect, and how this led to end to end control on network that support mobile operators to enhance the quality with effective resources management and utilization. Moreover, according to this research the NFV opens new revenue streams and support mobile operators to introduce new services for business to business, business to consumers, and beyond that to reach business to business to x services that it raised after digitization age, where the services is core part of customer/client' value chain, in addition to that, NFV supports mobile operator to enhance the time to market required to develop or deploy new solutions, as well as its significantly optimized their product portfolio with new offerings that targeting new markets or segments. In numbers , it's expected to increase the number of Mobile operators offering to more than 200% benefiting from NFV that engaged mobile operator with open APIs ecosystems, and in same time reduce time to market by more than 90% by applying agile service development methodologies with automated functionalities and high scalabilities that supported by NFV. Further, this study sees that assets sharing model of virtualization/NFV will significantly enhance the cost of

service and could be offered as infrastructure as a service model (wholesale revenue generator model), accordingly the study expects a revenue impact of 2%, 10% OpEx saving, and additional of 10% of revenue as CapEx per year to cover virtualization cost for the infrastructure base.

Juniper (2017), had focused on what are the main aspects that mobile operator has to consider in developing its NFV business case, it's clear from the study that NFV role in network transformation toward agility and open ecosystems. Each mobile operator based on this paper has to conduct profit analysis for NFV for any use case before apply it on their networks, the profit analysis shall cover the expected revenue from new services that will be introduced by NFV agility and open ecosystems, in addition to the impact of NFV on scalability of existing services and products characteristics, as well as evaluate the impact of NFV and virtualization on network OpEx and CapEx required to deliver service with same or higher quality. From other prospective the operational excellence should be considered to evaluate the non-direct impacts on financial KPIs, such as reduce legacy system vendor risks, vendors leverage, degree of operation leverage. In conclusion, the paper discussed different analysis modeling that could be followed to evaluate the business case for each NFV use case. However, there is a risk assessment that should be conducted to avoid any negative impact in applying NFV.

Based on Vorst et al. (2018), NFV technology is not exclusive on operators, also it can be used in ISP networks as it represents an interest when it is implemented at the edge of network which apply an opportunity

for ISP companies to offer new services especially in network security and service delivery.

NFV could also be used in internet-facing private and internal privet networks, as NFV optimizes resources with lower cost and effective management, however NFV technology is still limited to be applied on transit networks due to its nature of network requirements.

Visualization effect on business model expected to be major according to its progress in structural management through reducing the complexity of network, also virtualized infrastructure could be exploited to expand business vertically by creating new market opportunities such as capacity leasing to virtual operators and ISP providers.

Pure concept for NFV technology perform a risk for network security and privacy as it breaks physical separation of networks. So attacks will be easier as physical obstacle will not be existing any more ,particularly if the vendor of hardware is not trusted, however this risk is not a stopper for NFV technology implementation .as connection will be encrypted end to end .

NFV has a dramatic change on competition rules between network vendors and services provider as it unifies the hardware requirement of network so profit that comes from legacy hardware will decline and competition focus between network vendors will be on software that fit vitalization requirements with best performance in term. However NFV is an opportunity for operators to have better competitive situation in the market

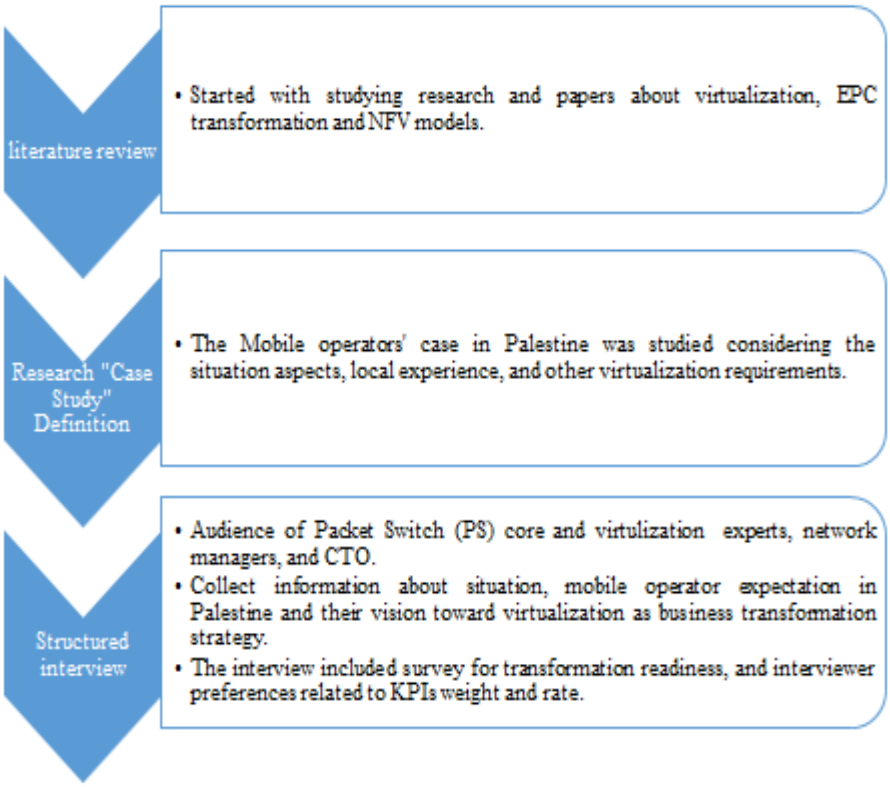
through the ability of providing new services and meeting high demand requirements.

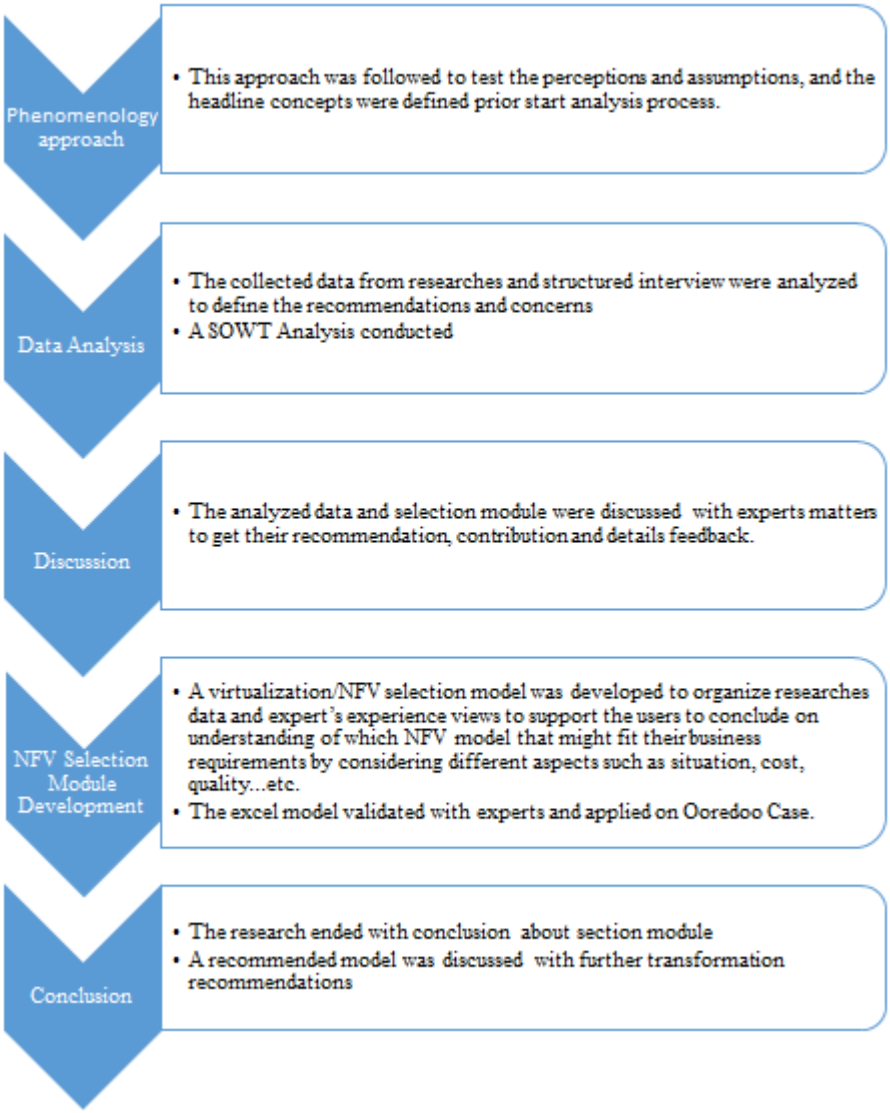
This Research focuses on third generation evolved packet core network to find best deployment or service model that can be applied on Palestinian operators which have special political characteristics political and considered as an emerging market.

Chapter Three
Research Methodology

3.1 Overview

This research addresses a subjective experience topic that searches out for the best EPC practical model to be applied for emerging markets based on technology facts and operation experience. Thus, the analysis of research was built based on qualitative method using phenomenological interviews, and analyzed the collected data using deductive approach. This methods were used due to limited existing experts in this domain in addition to limited operators available in Palestinian market following flowchart the flowchart of research methodology.





3.2 Research Approach

This study was built based on qualitative approach .However a quantitative approach was used in simple partial of research which will be clarified later in EPC selection model in this chapter. The research was built on phenomenology approach which depends on interviews with experts and past Experiment with virtualization in other department from network.

3.2.1 Phenomenology

According to (Nyberg & Berg) 2014, Phenomenology is specific qualitative study method that reads and analyzes subjective experiences of experts on their domain. It studies the opinions and the experience point of view for different persons with different experience interpretation.

The philosophical basics are the core of this approach that researches the main meanings and findings of different person's experiences to formulate a mutual understanding and reach out the main mutual essences for all these experiences. Each experience has its own conditions and situational judgment that considered to apply what is applicable on the selected case study.

The data collection in the phenomenon approach uses "phenomenological interviews" which follow three main process bracketing, phenomenological reduction, and horizontalization starting from design ending up with analysis. At early stage of research, the researcher developes his point of view, experience perception, initial expectations and assumptions in a process called bracketing that enables researchers to define the subjective experience shape of the research topic. While at phenomenological reduction process, the researcher starts studying person's experiences along with case details and situation to be able to describe the case and determine the applicable experiences that fit case study, ending up with data organization and experience classifications to conclude on the common

experience understanding of the topic and case study in a process called horizontalization.

The Phenomenology approach was applied on this virtualization research as the nature of the study requires understanding the situation and other expert's subjective experience for different NFV models and different use cases. Thus, the research started with studying a lot of research papers about virtualization and NFV models, studying different NFV use cases for mobile operators, and focusing on the study of EPC transformation from legacy to virtualization using NFV models. In the next phase of study, the Mobile operator's case in Palestine were studied considering the situation aspects, local experience, and other virtualization models requirements for each case. At the end of study phase an initial understandings and expectations for research developed with full case study description, and the applicable virtualization model for the case study is determined based on the understanding of the situation and experts' point of view. Further, a virtualization/NFV selection model was developed to organize researches data and expert's experience views to support the users to conclude on understanding of which NFV model that might fit their business requirements by considering different aspects such as situation, cost, quality ….etc., and model provide user free hands to select which aspect has the higher priority in his case.

3.2.2 Interviews

Depending on (Nyberg & Berg) 2014, the interviews is one of the most popular approaches to collect the data for a qualitative research and main part of Phenomenology approach. There is different ways to do interviews: face to face, outbound call interviews, focus groups interviews, and expert's interviews. The interview could be used an pre define statements or questionnaire which is called structured interview, or via free conversations that allow for interviewer to discuss more topics and views to collect data as much as needed in a shape of unstructured interview.

Moreover, the interviews enables researchers to collect the required information about the research topic and gain more information about the experience and the point of views that audience have. And as mention previously "phenomenological interviews" allow researcher to collect information about other person's experience.

The interviews on this research were developed based on structured interview targeting an audience of PS core experts, network managers, and CTO in a mobile operator in Palestine to collect more information about situation, mobile operator expectation in Palestine and their vision toward virtualization as business transformation strategy.

3.3 EPC Selection Excel Model

The EPC selection excel model was developed to enable the mobile operators to select the most suitable NFV Model that fit to their EPC business transformation from legacy to vEPC.

The model start from readiness survey to evaluate readiness, then moves to KPIs rating, KPIs weight, and ending with recommended model meet their business needs according to the mobile operator inputs used in the model.

3.3.1 Readiness Survey [1]

The readiness model sheet prepared to support the mobile operators to evaluate their readiness to get choice of start the business transformation from legacy systems to virtualization.

In same time the survey support minimizing the influence of personal perceptions or any kind of bias using scientific approach. Which leads to have logical indications to start in network virtualization or to enrich mobile operator case to enhance their readiness for virtualization.

The readiness stage aims to facilitate the company readiness measurements from different perspectives, starting from the level of NFV knowledge that mobile operator's team has, management awareness of transformation effects, team capabilities to deal with transformed systems, in addition to the operator planned strategies to get indication about their mutual impacts

[1] The survey used scale (4→ full comply, 3→ fair comply, 2→ weak comply, never comply). Refer to Appendix A

on each other. This thesis survey focuses on EPC system as the selected use case is transforming the core data network from legacy systems to NFV.

The questions started with estimation of operator ambition for EPC-NFV technology, by short statements describe whether the operator put forward EPC-NFV for discussion .

Then presented new statements to perceive the company overview of EPC-NFV effect on their business services from commercial perspective, considering the effects on service value proposition.

Thus, the change challenge on the whole organization including existing systems, people and process are assessed in the statements, and consequently the impact pf NFV on existing system process performance and operations that related to end customer or even internal customer could be rated in scientific approach.

Further, the survey perceives EPC-NFV strategy prioritizing from management perspective, and expected added value to the operator, in addition to define technologies that might depend on vEPC.

3.3.2 Model Rating Matrix [2]

A matrix rating model was prepared according to reputable references of different use cases and studies. The matrix support the mobile operators to rate the available NFV models according to defined KPIs.

[2] Refer to Appendix B. Rate used scale (4→ full achieve, 3→ fair achieve, 2→ weak achieve, never achieve).

A qualitative method used to rate most of the general KPIs that are same for all mobile operators regardless of their aspects. While the cost KPIs rated using a quantitative method, since the cost KPIs are vary from one operator to another based on different drivers such as mobile operator size (subscriber number), operator's vendor cost and other elements.

The cost rating model was developed based on two main sheets "Cost input Sheet", and "Cost index sheet", in addition to a cost summary sheet that present the models cost rate.

3.3.3 Cost Input [3]

The cost inputs are varies from operator to another depending on many factors, common factors clarified in the cost input sheet, however the model flexible enough for any operator with additional cost elements that can be added in the input sheet in order to be addressed in the business cost modeling and calculation.

3.3.4 Cost Index [4]

It is an driver sheet that gets the input from cost input sheet to estimate the total cost for each scenario, so the rate of cost KPI will depend on results of index sheet, as it represents business case for vEPC transformation scenarios.

[3] Refer to Appendix C
[4] Refer to Appendix D

3.3.5 Cost Summary

A normalization sheet for the result of driver sheet that presents the output of cost model and the rate for each scenario.

3.3.6 Weighting Matrix [5]

The matrix is to prioritize defined KPIs according to the business strategy, technical approach and transformation trigger views. The mentioned perspectives should be taken into account to weight KPIs in an objective and appropriate way. The decision for weighting will differ from operator to another relaying on variation in decision power distribution between mentioned perspectives. Which is recommended to be set by selected committee from the mobile operator management (business and technology) to take the most suitable and validated decision.

[5] Refer to Appendix E weight used scale as a range (5= (80-100) %, 4= (60-79) %, 3= (40-59) %, 2= (20-39) %, and 1= (0-19) %).

Chapter Four
Case Study

4.1 Introduction

According to Wataniya Mobile (2016), Ooredoo Palestine a member of Ooredoo Group, Ooredoo Palestine is the second mobile telecom company to have been licensed in Palestine, and whose network currently covers 96.5% of the Palestinian population in the West Bank and Gaza Strip. Ooredoo Palestine aims to bring the latest mobile technologies and highest quality service to both individual and commercial customers in Palestine".

Ooredoo Palestine started commercial GSM services in West Bank by 2009 and in Gaza by 2017, Palestinian telecom market suffers from occupations' obstacles that prevent operators from introducing new technologies to customers.

As third generation services (3G) were launched in 2018 only in West Bank region after obtaining the required permissions and approval from Israeli Authority to allocate and use 3G Spectrum for both Palestinian mobile operators, in addition to get approvals to deliver and enter the 3G network elements to the country, where it was prevented by Israeli side to use the 3G spectrum by any of Palestinian operators, and even it was not allowed to deliver any of 3G network elements.

In addition to Israeli limitation on entering equipment related to existing network by the complex procedures that waste resources, mainly time and money. This issue has impacts on different perspective for Palestinian

operators mainly on revenue, beside other effects on customers' dissatisfaction due to delay in introducing new services, thus Israeli managed its' restrictions in a way contributes in customer guidance to use existing Israeli operators service, accordingly this created the illegal competition whose perform one of the most dangerous threats on Palestinian operators.

Ooredoo Palestine struggles in risky market with illegal competition from Israeli operators, they have to be ready to unexpected and urgent events such as increment in number of subscribers, market campaigns which needs core changes and new business trends and move from technology to another smoother as much as they can.

4.2 Ooredoo Palestine IP network

Ooredoo Palestine core network was designed to handle 3G traffic, however this will be different in next generations as existing network will not be sufficient to handle the huge traffic in next generations with required quality.

For IP core network, the existing elements in Ooredoo Palestine Network are MGW, HLR, GGSN, and SGSN.

Media Gateway (MGW)

According to Cisco (2002), MGW is a converter for media streams between different telecommunications technologies such as 2G, 2.5G and 3G.

Home Location Register (HLR)

Based on Cisco (2002), HLR Contains the data related to users such as location and authorization, for HSS, it is a modernized HLR with Authentication center.

Serving GPRS Support Node (SGSN)

As mentioned in Cisco (2002), SGSN is an element of the GPRS network that handles all packet switched data within the internal network.

Gateway GPRS Support Node (GGSN)

GGSN is an element of the GPRS network. Referencing to Cisco (2002), it is responsible for the interworking between the GPRS internal network and external packet switched networks.

4.3 Core Network Ooredoo Palestine SWOT Matrix

SOWT analysis used to discover the most needed strategy for Ooredoo Palestine from lists of company's strengths, weakness, opportunities and threats.

4.3.1 SOWT Analysis

This part aims to clarify the company strengths and weakness, and clarify the Opportunities and threats in order to Plan for more powerful strategies that could benefit from company strengths and opportunities to get rid of existing company weakness, increase company strength points, and limit threats impacts.

Strengths

Ooredoo Palestine is a part of Ooredoo international group that enriches Ooredoo Palestine trademark, especially in vendor management. Also Ooredoo Palestine Network is modernized network comparing with local competitor, thus Ooredoo Palestine GSM and third generation networks provide services with quality on both voice and data services. In addition Ooredoo Palestine Network has competitive capacity to handle customers demand with high quality in third generation network. Moreover network team skills robustness one of the most essential strength point for Ooredoo Palestine.

Weaknesses

Ooredoo Palestine is the second operator in Palestine (West Bank, Gaza) as mentioned it started its GSM commercial services by 2009 in West Bank after 11 years of local Competitor monopolism for West Bank market, Moreover Ooredoo Palestine started its GSM commercial services in Gaza by 2017 after 19 years of monopolism from local competitor so it is expected that number of customers related to Ooredoo Palestine is less than local competitor. In General telecom operators around world suffers from decrement in EPIDTA and OpEx increment. However Palestinian operators are special case as Israeli restrictions and limitations contributed clearly in EPITDA decrement and OpEx increment more and more.

Opportunities

Ooredoo Palestine aims to be first choice for customers through providing new services with optimum leading time and highest quality.in addition, once Israeli allow Palestinian operators to provide any new technologies services , Ooredoo Palestine seeks to introducing them with shortest implement time.

Threats

The political situation for Palestine is reflected on all existing fields such as telecom industry which suffers from Israeli restrictions on applying new technologies and equipment' entering to Palestine. Moreover, the illegal competition from Israeli operators that provide advanced technologies which are blocked to be introduced by Palestinian Operators until an unspecified time, all this existing limitations affect vendors availability in Palestinian Market . Also worldwide OpEx increment and revenue decrements for telecom operators, in addition to high investment is needed for new technologies.

4.3.2 SOWT Aanalysis Strategies

The result of SOWT analysis are the strategies that come from matching (strengths ,Opportunities) ,(strengths, threats),(weaknesses ,opportunities)and (weaknesses, threats) with that company should follow to enrich Ooredoo Palestine by improve its strengths and limits its weakness ,the key points of strategies is mentioned in

Table **2** SOWT Matrix – Template for Network Wataniya Mobile, virtualization strategy is a main strategy resulted from SWOT analysis.

Virtualization is a key strategy for Ooredoo Palestine to reduce the impact of mentioned threats. So Ooredoo Palestine aims to turn its' IP legacy network to IP virtualized network.

This study case focus on selecting the best business model based on Ooredoo Palestine vision.

The excel model will be used as an structured interview with Ooredoo Palestine IP core Manger, network project Manager and CTO to determine the readiness and most suitable model that fits Ooredoo Palestine current and future needs taking in to consideration its readiness.

Table 2. Control difference between NFV models.

Internal / **External**	**Strengths (S)**	**Weaknesses (W)**
	S1: Modernized core network.	**W1:** Low EBITDA
	S2: Improved network team skills.	**W2:** Number of customer is less than local competitor due to their monopoly in the market for so long time.
	S3: Core network has the capacity due to suitable network planning to handle customers demand with high quality.	**W3:** High OpEx
	S4: Ooredoo Palestine is a part of international group (Ooredoo group)	
Opportunities (O)	**SO Strategies** Use of internal strengths (S) to take advantage external opportunities (O).	**WO Strategies** Use of external opportunities (O) to overcome internal weaknesses (W).
O1: Be the first choice for customers.	**S4O1:** Use the Brand Power to attract customers.	**O1W2:** Customer's acquisition strategy
O2: Provide new services with optimum leading time and highest quality.		**O1W3:** Digitization Strategy
O3: Implement new technologies with optimized time.		**O2O3W2:** Virtualization Strategy.
Threats (T)	**ST Strategies** Use of internal strengths (S) to avoid or reduce external threats (T).	**WT Strategies** Strategies to minimize internal weaknesses (W) and possibly reduce external threats (T).
T1: Israeli restrictions on applying new technologies.	**S2T2T6:** Virtualization Strategy.	
T2: Israeli restrictions on equipment' entering to Palestine.	**S2T6:** Training strategy (invest in the employees).	

T3: Increment in OpEx and decrements in Revenue in Telecom industry.	**S4T3T5:** Using group Purchase Power.	
T4: Illegal Competition from Israeli Operators.		
T5: High investments are required for every new technologies.		
T6: Limitation in Vendor due to existing restrictions.		

Chapter Five
EPC Models

5.1 Introduction

Based on ETSI (2013), the NFV has a lot of service and business models, this study considers five models that have different use cases on the mobile operator's networks: NFVIaaS, VNPaaS, VNSaaS, fully Owned NFV and legacy system. Figure 11 illustrates the main service control difference between NFV models, as it is clear more control on service require more capital investment from mobile operators, more operation efforts, and less of services offered by virtualized network functions service providers.

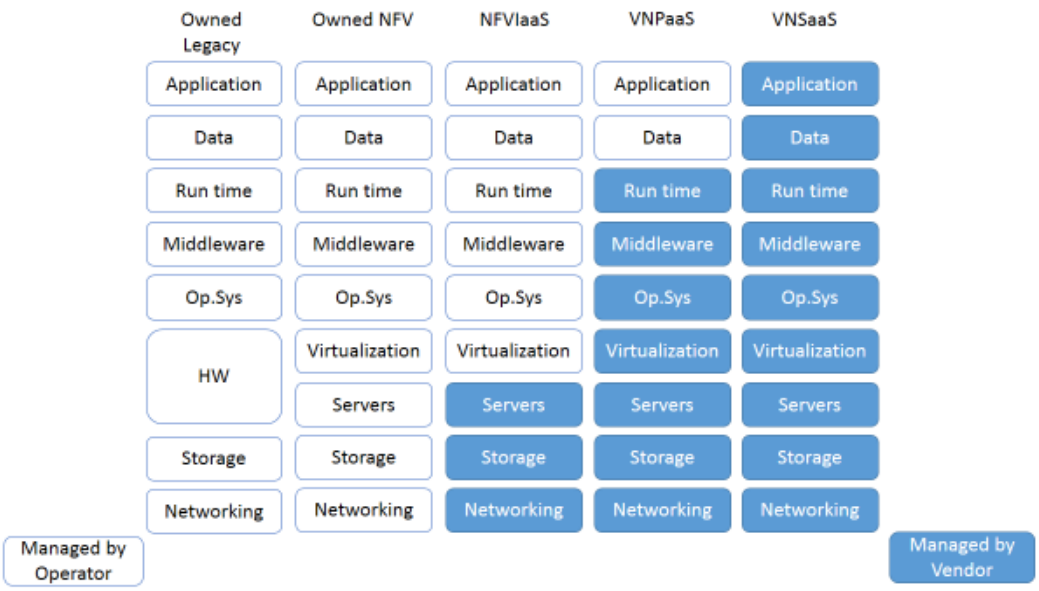


Figure 11. Control difference between NFV models.

Meanwhile the business model is the structure that assists the sustainability of a business, including its vision and mission to achieve its goals and ongoing plans. They are looking into operator infrastructure and service

offering development and reducing some impact also for the vendor ecosystem. The service model represent the business model if the model chosen to be cloud model (IaaS,PaaS,SaaS).Mean while owned legacy and owned NFV are owned model for the operates.

As service model is refer to any IT services that are provisioned and gotten into from a cloud computing vendor. This term includes all delivery and service models of cloud computing. Cloud services are delivered over the internet. The choice of service model or owned models for virtualization impacts operators business models in different ways, as Network virtualization offers a great business potential, in terms of cost savings and additional revenue sources for operators and innovation opportunities.

5.2 Network Function Virtualized Infrastructure as a Service (NFVIaaS)

As mentioned in ETSI (2013), Network Function Virtualized Infrastructure as a Service (NFVIaaS) is a model that offers to customers/operators suite of infrastructure services including processing, storage and fundamental computing resources same to cloud IaaS along with dynamic network connectivity services as Network as a Service (NaaS). Or it could be offered from department to another in the same mobile operator organization. However, the main drivers for mobile operator to select NFVIaaS model for their specific use cases are usually related to performance objectives (e.g. latency, reliability), regulatory requirements, or cost optimization.

In the common practices for NFVIaaS, an NFVI/cloud infrastructure service providers offer NFV infrastructure set of resources (computing, hypervisor, storage, network capacity, network termination, dynamic network connectivity etc.) to another service provider (e.g. Mobile Operator) according to commercial service agreement between both parties including specific SLA. Mobile operators shall be able to run, deploy and integrate its VNF function/application on the provided NFV Infrastructure for NFVI service provider.

The core target of NFVI is to provide proper virtualized implementation environment to run different functions and applications. To achieve this, smooth operational life cycle shall be supported by NFVIaaS to offer appropriate infrastructure services for different functions and different mobile operators in the same infrastructure. Moreover, the service supply chain in the NFVIaaS has to be through constructive administration framework to manage across administrative boundaries between different functions or mobile operators.

The mobile operators usually pick the NFVIaaS service provider based on commercial agreement terms such as NFVI availability, capacity constraints and other infrastructure limitations for service horizontal scale and vertical scales, and service SLA, and accordingly all of these are reflected on commercial prices. Therefore, mobile operator has to pay more attention on the commercial terms that support its business objectives.

NFVI can be a solution for Mobile operator to improve service resiliency by running the service on different distinct and independent NFV infrastructures. Thus, if failures occur on one NFV Infrastructure will be independent on the other running NFV infrastructure. Such redundant setup will provide mobile operator a higher resiliency service than it could rely on one NFV Infrastructure. However, this setup requires proper mechanisms to manage failure recoveries across validated independent NFV Infrastructures with different administrative domains.

Further, Mobile operators use NFVIaaS Model for different applications to reduce latency by deploying NFV closer to end user service network, one of these application is content delivery network CDN by deploying the CDN network close to end user service network and do content caching which leads to reduce latency and cost. Another application is specific EPC functions that can be deployed closer to RAN in order to reduce latency, and improve service throughput from end user prospective. However, this require proper mechanisms to monitor and predict latency in each functions particular deployments or planned deployments.

Moreover, regulations might influence the NFVI deployments negatively or positively. Mobile operators in each country have set of regulations polices must to comply with, such as geographic constraints of the end user information storage location and processing environment locations. Mobile operators have to choose NFVI service provider based on its infrastructure environment geographic location. Other policies might introduce new NFVI deployments or commercial agreements to enrich economic cycle,

such as introducing authorized national NFVIaaS service provider to run and host different functions for different operators for appropriate investment management by having one shared infrastructure for different operators, which lead to reduce end user service cost and support environment policies.

The NFVIaaS model has a lot of concerns and aspects that need more attention from mobile operators and service providers. NFVIaaS has security concerns as mobile operator doesn’t control the infrastructure layer neither control the infrastructure access that managed by NFVI service provider. NFVIaaS has operational complexities related to infrastructure administration, monitoring, and infrastructure resources allocation. And this require well orchestration management of VNF instances along with proper authentication and authorization mechanism to allow VNF instances execution on NFV infrastructure for authorized ones only as well as manage physical access to infrastructure environment. Other concerns are to have proper SLA measurement mechanism between mobile operator and service provider, and to have efficient reporting tool for failure notification and diagnostics management that keep mobile operators informed about NFVI performance to avoid any impact on the end user services. Other Models provide service beyond the infrastructure such as VNSaaS and VNPaaS.

5.3 Vitalized Network Software as a Service (VNSaaS)

As ETSI (2013), clarifies that Vitalized Network Software as a Service, (VNSaaS) provides Customers the ability to use SW applications, the consumer can manage application only from configuration prospective, and can't control the underlying Infrastructure nor manage the Virtualized Network Functions VNFs. While,

The VNFaaS that used by mobile operators is using the concepts of VNSaaS, the mobile operators doesn't need to invest in infrastructure or network functions applications as they can purchase these functions as service from the service provider in OpEx basis whenever its needed. The VNFaaS use the following SaaS model advantages in VNSaaS model:

- Modernized software and tools that ensure service with high availability
- software licenses efficient utilization and proper management
- Data and Management are centralized
- Minimize initial investment

The development in the VNFaaS and VNSaaS is leaded to introduce a lot of use case that use this software model, where the mobile operator purchase function or software as service from specialized services providers in their domains. An examples of the deployments for this models in Mobile operator's networks are: CPEs (customer premises equipment), network firewalls, DPI (Data Packet inspection within PS

core), IPS (intrusion prevention system), and network performance monitoring ….etc.

This model can be used by Mobile operator from different prospective rather than get functions from service providers a service, to provide services to their B2B customers beyond legacy access services. The Mobile operator can deploy VNSaaS within its network to provide customers routing, security, and network connectivity functions as a service. As using the VNF concepts enable mobile operators to manage their resources effectively using resource sharing to generate revenue from their B2B customer and in same reduce setup and operational management costs.

5.4 Vitalized Network Platform as a Service (VNPaaS)

ETSI (2013), Continue to clarify that Vitalized Network Platform as a Service (VNPaaS) is suite of infrastructure and application as a platform, mobile operators can deploy network applications and develop their network service customized to their business purposes using the provided platform.

As VNSaaS and NFVIaaS the same can be achieved using the VNPaaS model, as Mobile operator can offer the available resources of infrastructure and software/applications as a platform for their B2B customers to run and deploy their network functions with flexibility to customize network service to fit to their business needs, examples on these functions are APN, Wi-Fi, and VPN.

Further, the VNPaaS and VNSaaS have a lot shared features and benefits, but VNPaaS have more flexibility and scalability that allows mobile operators as customer to do more application development, deployment and scale vertically as far as level of customization provided by platform. The VNPaaS provides mobile operators as customer more control on the application and data layers and allows customers to create their own VNFs.

VNPaaS provides a platform with all customization tools and dynamic network functions needed for application/functions development, deployment, and service administration in proper scalable structure that supports managing and processing huge data and large numbers of customers within virtual functions network.

There is a lot of VNPaaS model use cases within mobile networks such as: Firewall functions, and IMS (IP multimedia sub systems) networks.

However, both VNSaaS and VNPaaS have issues that must be addressed in any network deployment. VNSaaS main issues is the single-point of failure as VNF may not functioning properly due to any network connectivity issues or due to software bug. This challenging the provided functions as service quality level comparing to legacy networks where the mobile operator has full hands on control. Thus, it is required to have full service measurement and monitoring in the VNSaaS deployments provided by service provider to Mobile operators to minimize the quality impacts on network function services. In addition to isolate between mobile operators and customers functions in VNSaaS to minimize the security threats on

customers data and configuration files, as well as to avoid any quality impacts from customer misuse on other customers within the same service provider virtual network.

The same for VNPaaS, as service provide have to secure authorized user access control to API calls, load and resource mechanisms that separates function's workload from different mobile operators, and to provide a solid monitoring and measurement tools that control resources and manage utilization of infrastructure and Platform capacities in a way that doesn't impact customer services. And from security prospective, service provider has to deploy high service isolation and protections to prevent any management domain break out for any provided service within service provider virtualized network

The mobile operators are occupied with telecom vendor's special dedicated hardware that perform different functions within legacy mobile network. The mobile operators aims to swap their legacy vendor hardware to standard hardware. Thus, Mobile operators started deploying their own virtualized infrastructure to host and run special applications and functions far away from legacy networks. This model it could be could as owned NFV, where the mobile operator own all layers from infrastructure till the application with full control on the virtualized network functions VNFs and the service. Mobile Operators tend to this model to reduce investment in costly vendor hardware which mean lower CapEx, as well as reduce the operation expenses OpEx, and in same time to reduce the operation complexities of managing legacy network that requires certain level of

vendor hardware operation skills. Further, this model keep mobile operator services independent from any other service provider's issues and as well as their customers issues as it is the case in the NFVIaaS, VNSaaS, and VNPaaS but this has to be compromised with potential saving that might be achieved by deploying these NFV model instead of deploy the owned NFV model.

5.5 Owned NFV

ETSI (2013), Mentioned that owned NFV model which classified under on primes deployment model has quality advantages among other NFV models due to full control on all layers. In such environment the mobile operator has high flexibility to manage virtualized network resources between different network functions by allocating resources dynamically based on need and service demand to improve quality proactively. Therefore, in case one of the mobile network services (e.g. voice) had high demand which increase significantly due to particular market situation (e.g. natural disaster scenario; Earthquake that leads to massive demand on voice services), the virtualized network could support mobile operators to allocate the needed resources for this function or service to handle the abnormal demand in such situation, far away from applying control solutions of call restrictions that leads to customer dissatisfaction and revenue loss.

Further, owned NFV support mobile operator to optimize CapEx and OpEx, along with improve quality of service by utilize network resource

properly, increase service availability and resiliency with dynamic network functions, enhance network scalability by dynamic network functions capacity modifications according to load, dynamic topology reconfiguration for performance optimization, and provide vital environment for service innovation and creativity that removes vendor hardware limitations with dynamic allocated resources.

The main use cases of owned NFV in mobile operators are virtualized core network functions (e.g. virtualized PCRF, virtualized Evolved packet core vEPC, virtualized IMS …etc.).Figure 12 shows one of possible deployment of EPC virtualization based on NFV.

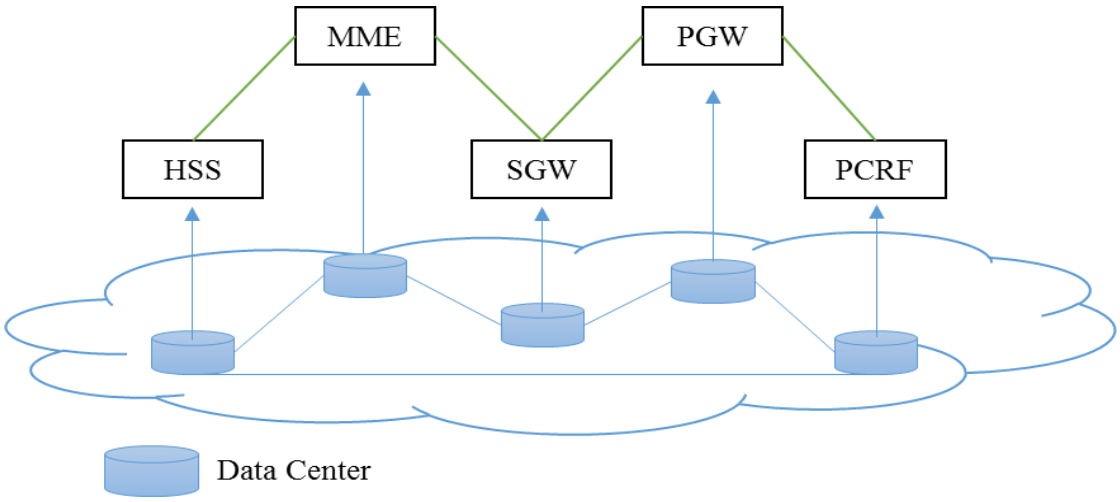


Figure 12. EPC virtualization based on NFV.

One of the main advantage of deploying Virtualized Network Functions EPC that each function can be scaled independently based on demand and performance requirement, in such virtualized deployment for EPC it could be increase the resources for specific function or service without affecting

the others, e.g. increase resources for user plane without any change or impacts on control plane.

However, in virtualized EPC achieving service continuity, availability, and resiliency requires proper dynamic relocation of VNFs for the managed sessions and connections to overcome any virtual machines (VM's) failure or overload.

Furthermore, in deploying the virtualized core network functions such as EPC, it should take in consideration the existing non-virtualized network functions to have seamless services flow, and seamless network control and management plane flow, regardless coexistence of virtualized and non-virtualized environment. To have proper monitoring mechanisms, fault management, and recovery solutions to manage all virtualized network functions effectively as same as the non-virtualized elements.

Also mobile operators have to consider the traffic data, traffic, and management separation logic for virtualized and non- virtualized core network function.

5.6 Owned Legacy System

The owned legacy model as NFV owned is on primes deployment model has advantage among other NFV models due to full control on all layers, which can be considered as the main differentiator for owned NFV and legacy system model. However such environment the mobile operator has rigid network resources, so different network functions requires different

resources according to the function nature. Therefore, high demand on network services requires more resources investment, so any abnormal demand shall be consider as a risk, which leads to customer dissatisfaction and revenue loss.

Further, owned legacy system requires high CapEx and OpEx, in addition to service availability and resiliency limitations.

Chapter Six

Targeted KPIs

6.1 Cost

One of the most important Key Performance Indicators in project management in addition to its importance for management to choose its strategies and plan that address their goal.

Based on Mijumbi et al. (2015), virtualization as a technology improved its efficiency in reducing cost whether it is CapEx or OpEx. In our study we focused on EPC system in network as it is the core of network.

However different implementation models have different cost reduction impact that affected by different internal and external factors such as but not limited to company scope, size, beside country polices and political situation.

Telecom industry trend moving toward cutting cost as it is one of the most costly existing industry which is consistent with virtualization. The selection for the model will be according to company's scopes as some classified to be CapEx ordinated other are OpEx ordinated or they tends to one of the classification and sometimes both

For CapEx oriented operators, they will try to reduce OpEx as much as possible, so the implementation model that will be choose will have the minimal OpEx , on the counterpart of OpEx oriented companies who will try to choose the model with minimal CapEx

Other operators that can't be classified under these two main categories, the management decide the required weight for both of expenditures CapEx and OpEx.

6.2 Quality

According to De Gouveia and Magedanz, (2009), in telecommunication industry, the Quality of Service is as a group contains certain level of service requirements offered by service provider's network to its end users, and without achieving this level of requirements the end user will not get the proper benefits of offered service or might lose some of its functionality. Therefore, a specific performance parameters are used to as indicators to measure Quality of Service provided to end user in the network such as latency, jitter, delay, service availability, packet loss…etc.

For Mobile operators the Quality of Service plays important role in the business market as differentiators from service to service and market to market, as it touches customer experience. So it could be the first driver for customer to select the service and provider even if the prices are higher comparing with other existing providers. In the mobile Data services, thus the mobile operators pay more investment and efforts to maintain or improve quality of service to have the best competitive position in the market.

However, based on Bo et al. (2015), introducing NFV by mobile operators requires them to consider its impact on the quality of service, by maintaining acceptable level of quality of service or improve it. In high

level the NFV has a lot of use cases that support improving the quality of service, one of most important use cases is deploying geo redundancy with low cost and less complexity that leads to improve service availability even at crises with optimal deployment. NFV deployment enhances the quality of service and customer experience by introducing sharing resources between different services or applications which means the higher service demand will get capacity from low demand service resources in dynamic service quality management approach that leads to serve customer with better quality in terms of latency and delay.

As Papidas (2016), mentioned that Deploying NFV in packet core/EPC has major impacts on the quality of service that vary from model to model, but in general virtualization environment leads to enhance capacity comparing with legacy EPC that is limited to special vendor HW capacity, accordingly this will lead to improve throughput from packet core side beside improving service availability and latency by combining different packet core functions. In addition vEPC/NFV provides rapid recovery time which improve significantly mean time to repair that enhance service availability.

6.3 Time to Market, Value Proposition, and Complexity:

In addition to quality, time to market, value proposition and operation complexities are other important factors have to be considered in any NFV deployment model. Nowadays, time to market is a differentiator factor for mobile operators to lead the market or to act quickly for new technology trends and business needs, which is strongly linked to value proposition, as

efficient time to market model will support the mobile operators to introduce new innovative services with optimized time. Therefore, the model complexities are considered to allow for this advantage, the model with less deployment complexities minimizes the time needed to launch new service.

Thus, FN Division Telecommunication engineering centre, clarified that mobile operators rely on NFV to gain rapid development and deployment for new innovative services with more agile network that has less operation complexities that allows them to scale up and increase capacity seamless at any needed time. While at legacy network usually any expansion requires new special vendor hardware, in addition to logistic time, installation time, and configuration time, which can't work efficiently in rapid demand or service innovation. NFV enhances the position of software entrants, small players and academia to benefit from the virtual appliance market, inspiring more service innovation to create new services and new revenue sources rapidly with lower risk.

Mobile Operators have already started introducing the NFV and SDN solutions on their networks to reduce the operational complexities and enhance the Time to Market by deploying fully integrated virtualized functions such as vEPC for packet core functions, which will open the door for new services innovation with more value proposition by inspiring openness and enabling a wide domains of eco-systems.

In general the deployed vEPC in mobile operators provides automated service workflow, automated network service chain, and end to end service deployment coordination through network function orchestration, which leads to minimize the service management complexities compared with legacy EPC. vEPC supports mobile operators to abstract underlying hardware, and allow services automation scalability and elasticity. It enriches service provisioning flexibility and reduces the time needed to deploy and integrate new services

The NFV met business needs to improve time to market by applying the following:

- Reducing the service maturation cycle.

- Allow to perform the production and test on the same infrastructure that provides much smooth and time efficient test, integration, and production migration.

- Remote software service provisioning for rapid services scaled up/down as required, and quick service deployment.

6.4 Security

Mobile security is one of the most important issue that operators and customers care about, it is can’t be a black and white; in addition it is impossible to get rid of threats, the challenge will be exist as the functions run, So the operator mission is to reduce the risk as much as possible it is not simply a case of protected or at risk. The probability of new complex

issues to be appeared increasing day after day, the security experts will not be glad when they find solution for specific security issues thus they totally realize that they will swamp in more complex issues which will appear and there is no specific solution could solve all existing and future security threats.

As one of the most important missions for mobile operators is data security and prevent any threats could affect data privacy so different security solutions are applied and systems security are tested continuously

Simha (2017), Explained that EPC system handles the network data function which require high security, so operators should take a security a major KPI in EPC establishment or changes. In virtualization technology one of the greatest challenge is in security, however this KPI will change according to deployment model.

Thus, turning EPC in to virtualize EPC should take in to account the security issues, and the existing region regulation that related to security, regardless the chosen model a risk mitigation plan should be established to minimize the consequences of security threats.

6.5 Regulation

As operators should follow the their region regulations and standards, the thesis focuses on special case which is Palestine, it is considered as an emerging occupied country ,which increases investment limitations and make it harder ,

Beside the internal country polices there are occupation restrictions which limit business. Telecom industry suffered since years from occupation limitations on this sector, one of the most obstacles for telecom industry improvement is hardware importation and delivery where the occupation stands as a stopper for special vendor hardware delivery, So expansion and migration from technology to technology (if it is allowed by occupation authority) may become awful to operators which will reflect on their services prices in a way that doesn't meet customer expectation comparing the prices of such services in the neighboring countries beside the illegal competition from occupation service providers, thus NFV will minimize the effect of occupation restriction on hardware availability by using standard hardware that is easy to deliver and available in the market even though the occupation restrictions.

Furthermore, the telecom regulation in Palestine is not mature enough due the absence of independent organization that manage the telecom sector regulations and following the global standards, as the best global practice is to manage the telecom sector regulation through "Telecom Regulation Authority" as independent entity, while in Palestine it is managed by Ministry of Telecom and Information Technology. Therefore, this limits the regulations that arrange and manage the NFV deployment models in the market between different service providers in away enhancing the telecom – economic development cycle; ex. No clear cloud services regulations.

Chapter Seven
Research Analysis

The research started with analyzing the company readiness to transform from legacy EPC to virtualized EPC, using a readiness interview with focus groups at network department in Ooredoo Palestine – Palestine.

7.1 Company Readiness

The readiness interview divided to different statement groups that evaluate the company readiness from different aspects. The first group start measure the company ambition toward the virtualization and mainly for EPC, the first group include different statements about the level of company strategy preparations made or planned to transform from legacy to virtualization.

From the consolidated interviews respond on virtualization ambition statement as below in Figure 13 it is clear that company has ambition toward virtualization in the EPC. Further, the company has plans to benefit from the virtualization to enhance the service value chain, and support the company to comply with new technology and business trends

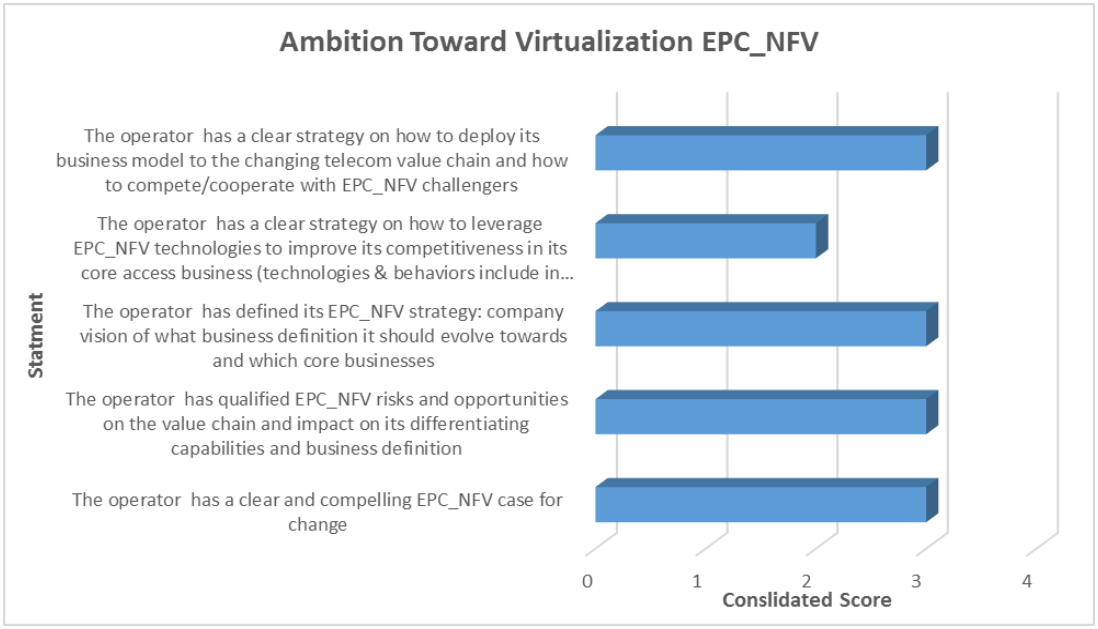


Figure 13. Ambition toward virtualization EPC_NFV.

The second statements group addressed the company strategy point of view from the EPC transformation toward virtualized EPC (EPC_NFV). The below Figure 14 shows that the company has strategic interest in the transformation to gain more competitive advantage, but in same time the company consider the virtualization as one of the important strategies that have to be in balance and aligned with other important strategies, which means the movement depends on other strategies importance and drivers.

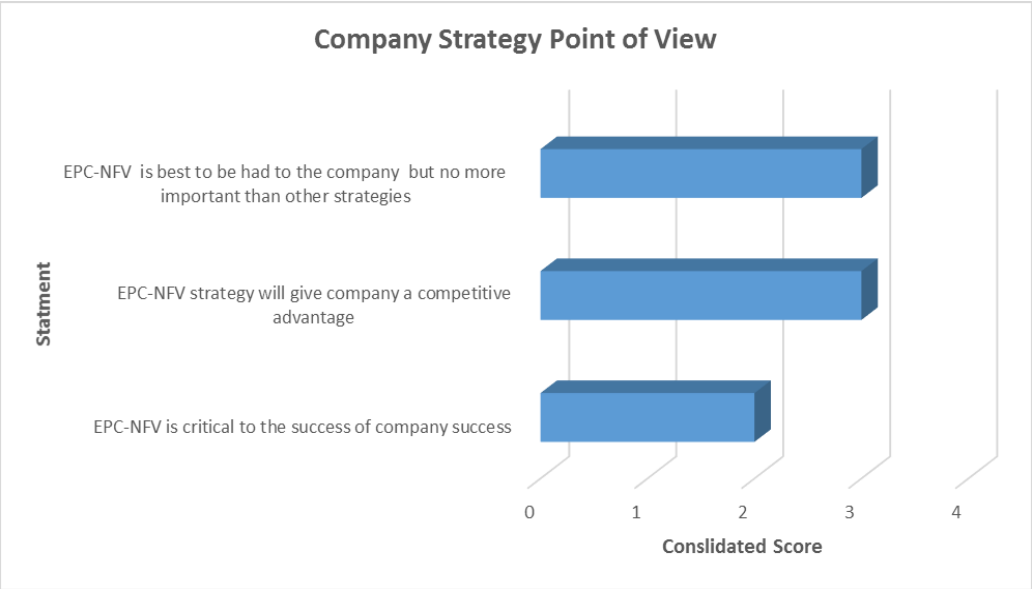


Figure 14. Company strategy point of view.

The company proposition or the business proposition is one of the main driver for any company strategy which the interview assessed in the third group of statements. From the focus group consolidated respond Figure 15, the company leverages on transformation and EPC_NFV to extend the value proposition, to act proactively for market demands in real time, and to support the enrichment of company's product and services portfolio. Which is aligned with measured company's strategic interest toward virtualization.

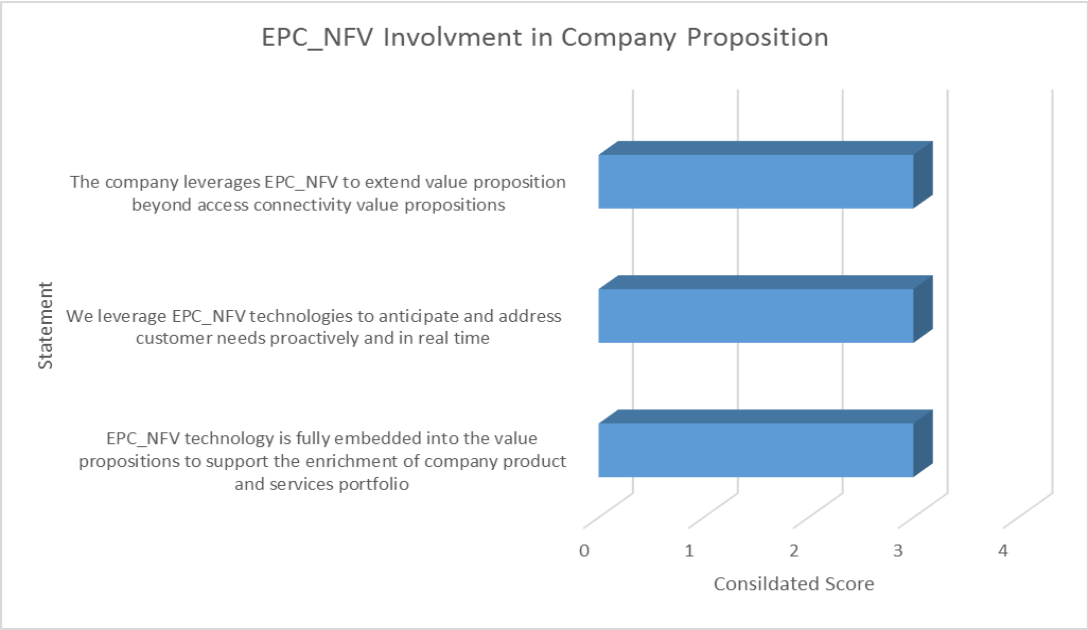


Figure 15. EPC_NFV Involvement in company proposition.

To enrich the company's products and services portfolio, then virtualization or EPC_NFV shall support new technologies enablement to motivate the company's strategy. From the fourth group statement answers Figure 16, the company is expecting from virtualization and EPC_NFV in their case to play an important role in introducing new technologies that are knocking the market door such as (OTT, IoT, Big Data, 4G …etc.). The EPC_NFV expected to enhance the service value chain and also the supply chain for these technologies to expand and meet market demand. The company is counting on EPC_NFV to handle the growing demand on 3G services with enhanced time to market, but moreover, they expecting increase in the IoT demand that require optimized scalable solution.

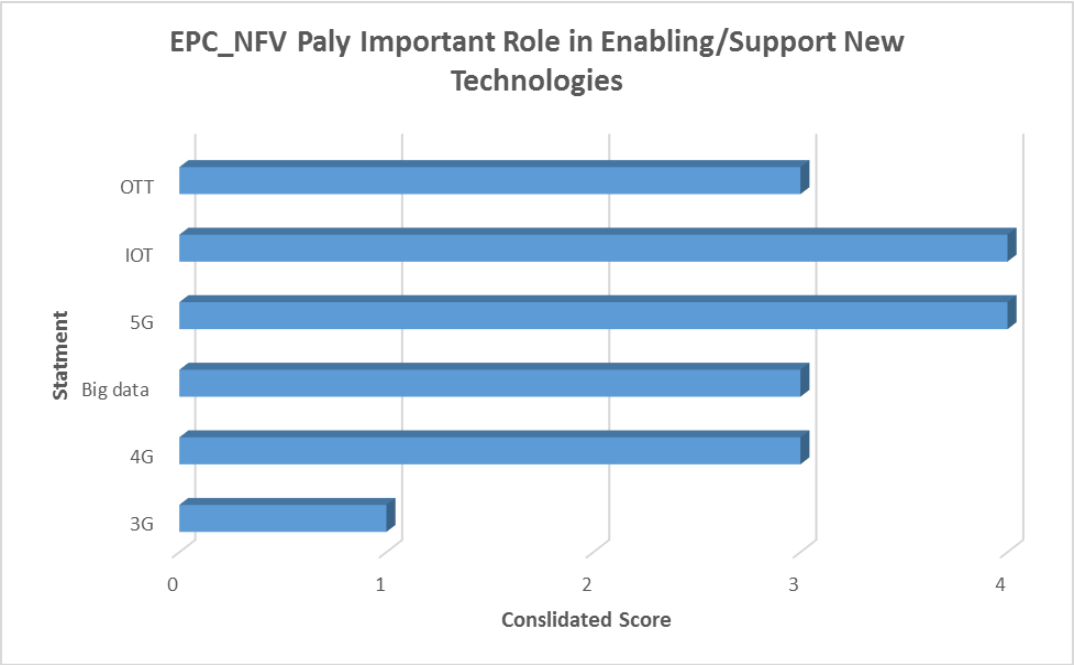


Figure 16. EPC_NFV Important roles in Enabling/support new Technologies.

The transformation expected to impact the company operation excellence. Figure 17 shows company response on how virtualization and EPC_NFV has positive impacts on the operation excellence in different domains. In overall, the company expect EPC_NFV to enhance the operation excellence in the most of the operation domains, and that mainly related to service (service planning, service deployment, service management & administration, and service marketing). In addition to positive impacts on procurement and supply chain, and the company investment.

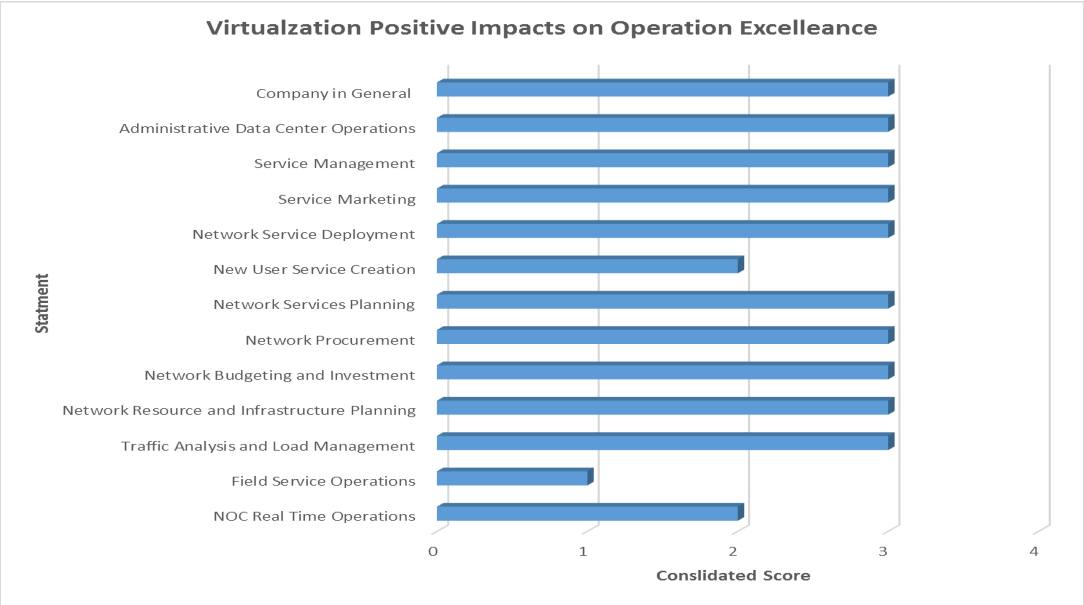


Figure 17. Virtualization positive impacts on operation excellence.

However, the company expects challenges that need to be addresses in the transformation from legacy to EPC_NFV. As noted in Figure 18 the company responds in shows that the first challenge is the information security, which follows by other challenges that mainly related to organization structure in terms of team skills, existing operation processes, and existing deployed systems and technologies. The company organization has to adapt in agile form that support transformation even at gradual phase for a part of the company or network as the case of EPC_NFV.

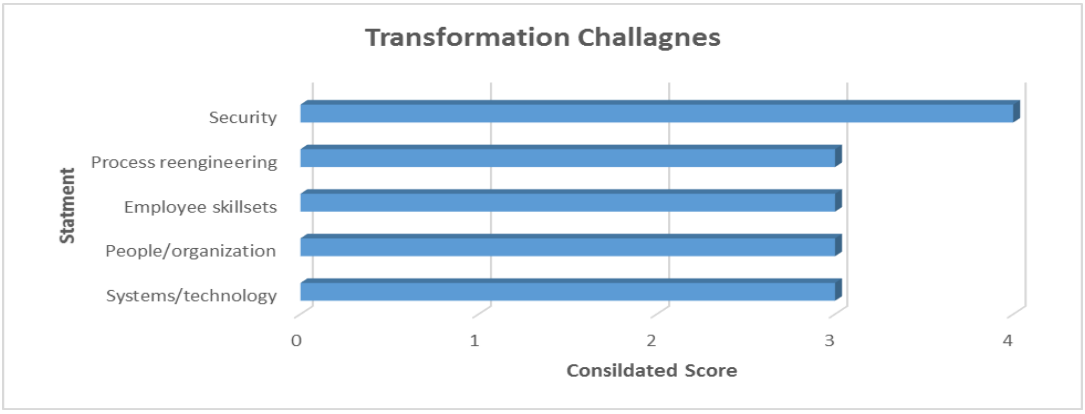


Figure 18. Transformation challenges.

In the end of interview, the company considering its particular situation has expectations from EPC_NFV as shows in Figure 19 having optimized PS core redundancy solution, overcome the political situation to enhance the service supply chain, and enhance service time to market are at the top of company expectations, on other words it's the main benefit that company looking for from deploying EPC_NFV.

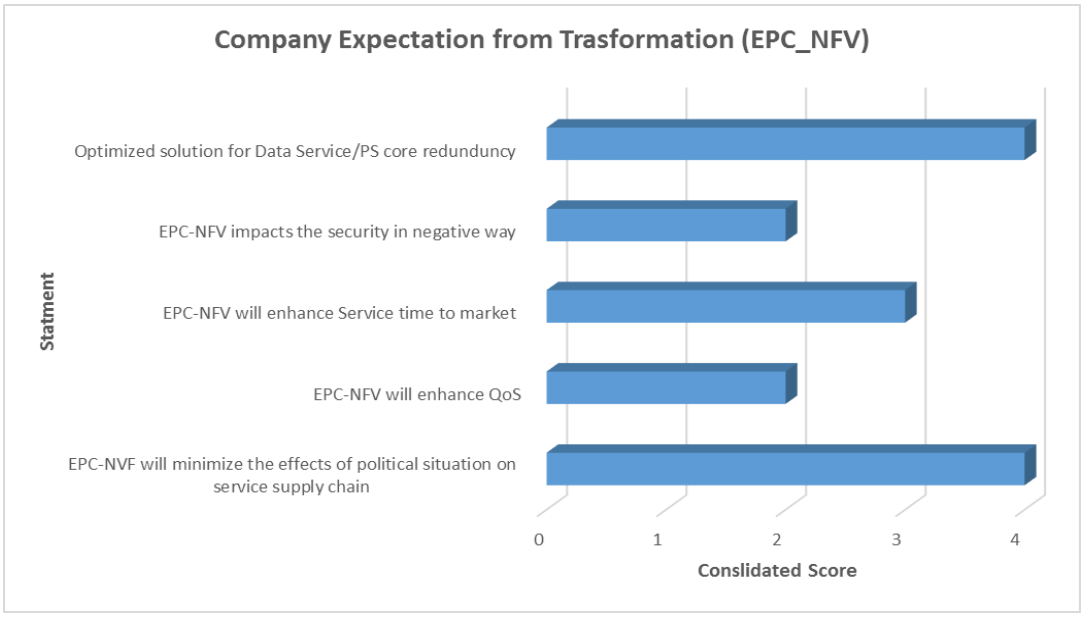


Figure 19. Company expectation from transformation (EPC_NFV).

The company has decided to start the transformation with EPC_NFV since it expected to enhance the service supply chain and competitive advantage for its core service, the data, which is the cash cow for mobile operators.

The company focus groups overall responds on the readiness interview phase summarize that company shows interest in the transformation toward virtualization and it embedded in their plans and short terms strategies. Moreover, the company has decided to start with EPC virtualization as step of long term strategy to transform from legacy network to next generation of virtualized network using the NFV and SDN models.

7.2 KPIs Weight

Since the company shows ambition to move forward in the EPC transformation and shows high level of readiness to transform, the next engine comes “KPIs Wight Engine” to evaluate and rate the most important KPIs that the company seeks to achieve considering their case characteristics from different angels: business strategy, transformation triggers, and technical deployment approach. Thus, a questioner developed and answered by focus group to understand the KPIs importance for the company.

The first question evaluated the most important KPIs for the company’s business strategy which has 25% from KPIs weight decision, as below Figure 20 the top KPIs for business strategy as discussed with focus group are: OpEx reduction, optimize time to market, enhance business proposition, overcome regulation and political situation that impact supply

chain, and improve QoS and mainly by having an effective redundant solution.

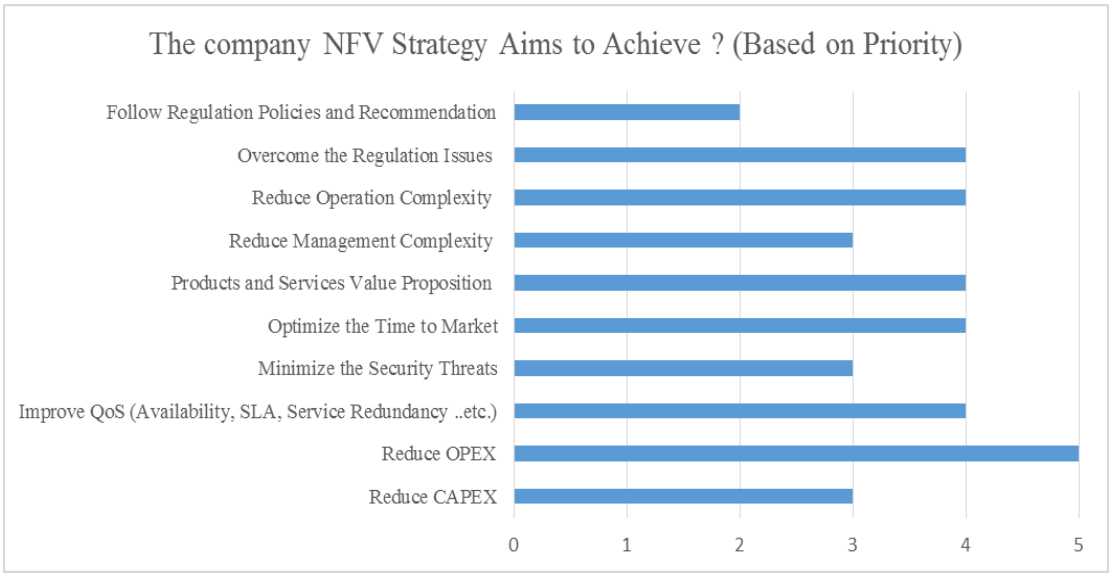


Figure 20. KPIs weight of Business Strategy.

From the focus group discussions, the main triggers that motivate the company to transform to vEPC has been defined as Figure 21 and the most important triggers are: OpEx reduction and deploy and optimized PS core redundant solution to minimize the risk of single point of failure to maintain higher service availability. The KPIs weight decision for transformation trigger is 15%

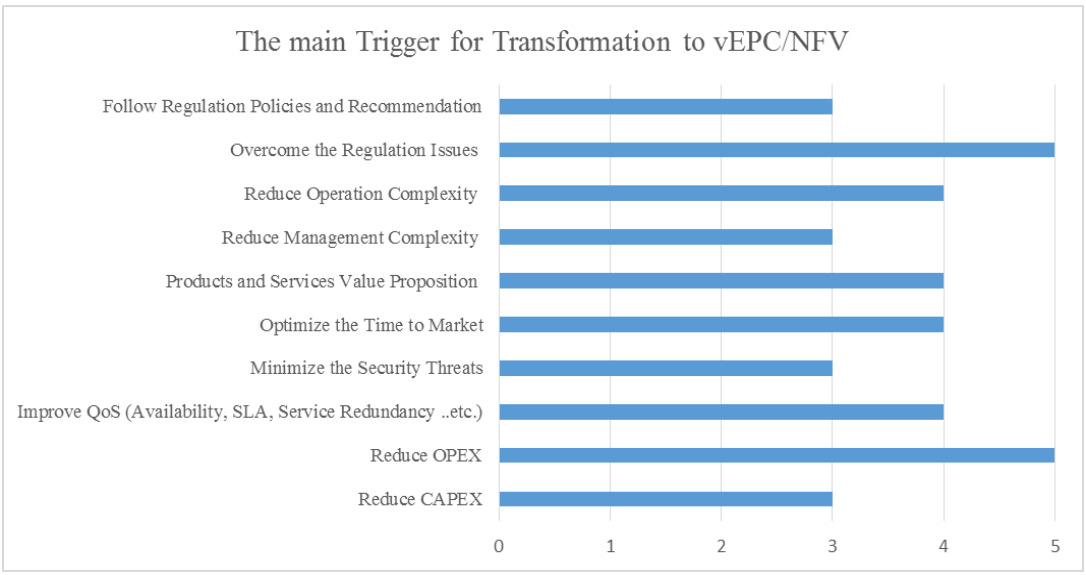


Figure 21. KPIs weight of transformation Trigger.

And even from the technical prospective which has the highest percentage of 60% for KPIs weight decision as shown in Figure 22 the company showed the same KPIs interest, as the company in the transformation deployment approach seeks to achieve mainly improvement in QoS by deploying redundant solution, reduce OpEx, and in same aims to reach high level of operation excellence.

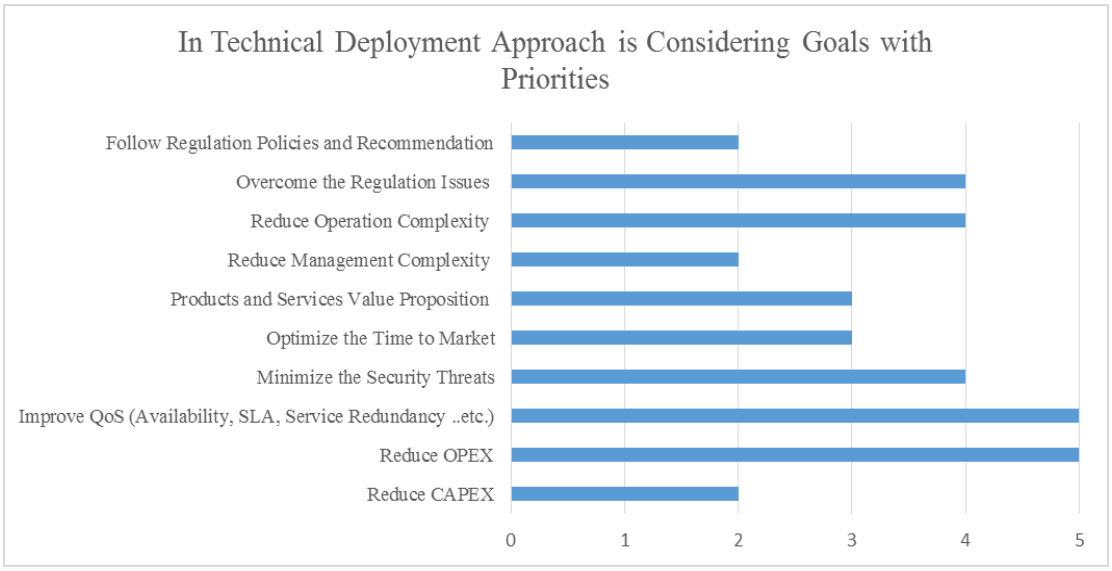


Figure 22. KPIs weight for Technical Deployment Approach

In overall and from the correlation of this section responds on the different KPIs prospective, the KPIs importance for the company case can be ranked as below after final discussion and alignment with focus group:

1. Reduce OpEx
2. Improve QoS (Availability, SLA, Service Redundancy ...etc.)
3. Overcome the Regulation issues
4. Reduce Operation Complexity
5. Minimize the Security Threats
6. Optimize the time to Market
7. Products and Services Value Proposition
8. Reduce CapEx
9. Reduce Management Complexity
10. Follow Regulation policies and Recommendation

7.3 EPC_NFV Models Rating

The next engine in this research developed to rate the applicable NFV models for each KPI for the company EPC transformation case, based on specialized NFV models studies, and case studies

7.3.1 Models Cost Analysis

Using the cost model engine the user can be able to evaluate and compare the financial drivers for EPC_NFV models and EPC legacy model based on his case study specifications. The model include inputs sheet where the user can define the business case drivers such as (forecasted number of subs, licenses, HW units, vendor prices …etc.).

For Ooredoo Palestine case, the drivers were collected and entered to the engine, and the summary generated as shown in Table 3. EPC CapEx & OpE

Table 3. EPC CapEx & OpEx.

Model[6]	CapEx	OpEx	Total
Legacy	$ 30,097,230	$ 18,118,648	$ 48,215,878
EPC NFV	$ 21,016,234	$ 14,950,470	$ 35,966,704
NFVIaaS	$ 14,353,234	$ 18,339,235	$ 32,692,470
VNSaaS	-	$ 39,035,871	$ 39,035,871
VNPaaS	$ 1,211,661	$ 31,703,671	$ 32,915,332

And the models ranked as shown in Figure 23 and Figure 24based on OpEx, CapEx, and overall. Where 5 is the top and 1 is lowest rank

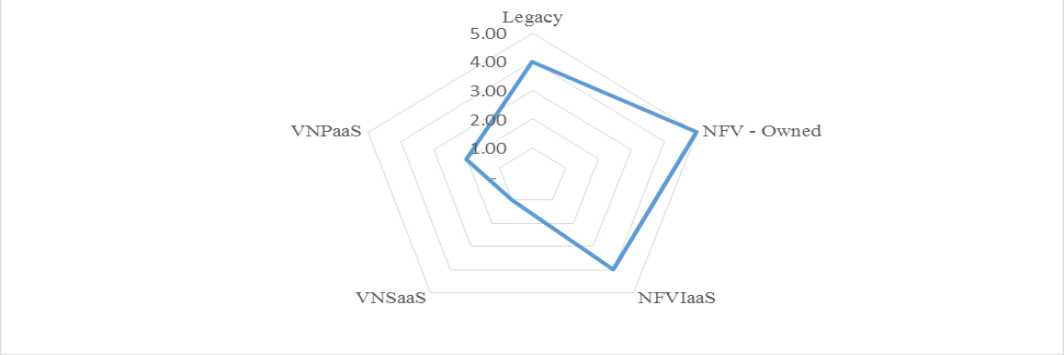


Figure 23. OpEx rate.

[6] Vendors average prices are used

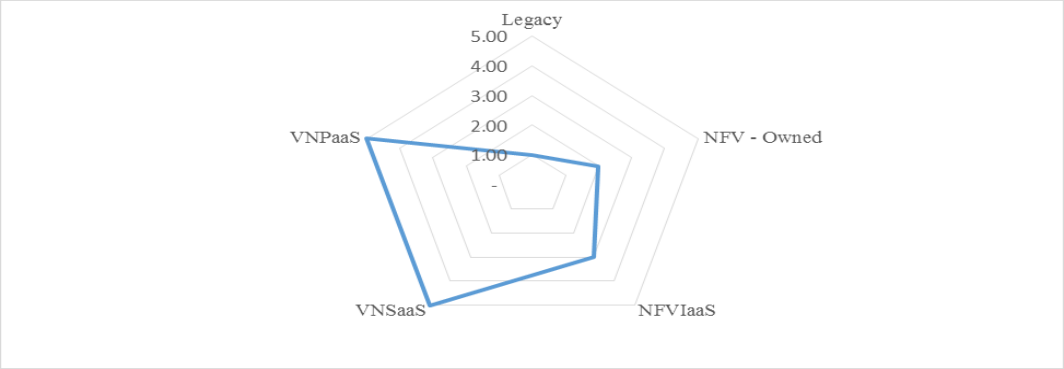


Figure 24. CapEx rate.

It is clear that the best models for Ooredoo Palestine from CapEx prospective are: VNSaaS, and VNPaaS, while from OpEx prospective the owned virtualized EPC (vEPC) is the best, and in overall the best models are NFVIaaS, and VNPaaS that mostly fit both CapEx and OpEx requirement.

7.3.2 Time to Market

The model support reducing time to market for new services.

owned NFV and NFVIaaS has the highest rate for reducing time to market as the operator could introduce any new service with minimal time due to its full control on all required layers, legacy EPC has the second rate as new service may require new legacy system that needs to be integrated with other systems in this case time to market will increased, NFVaaS has the next rate so new service may be implemented by vendor thus deliver time can’t be guaranteed even with SLA , VNPaaS vendor will manage technical requirement totally which leads to full control of time to market,

as NFVaaS deliver time can’t be guaranteed also there will be lead time which could extend time to market.

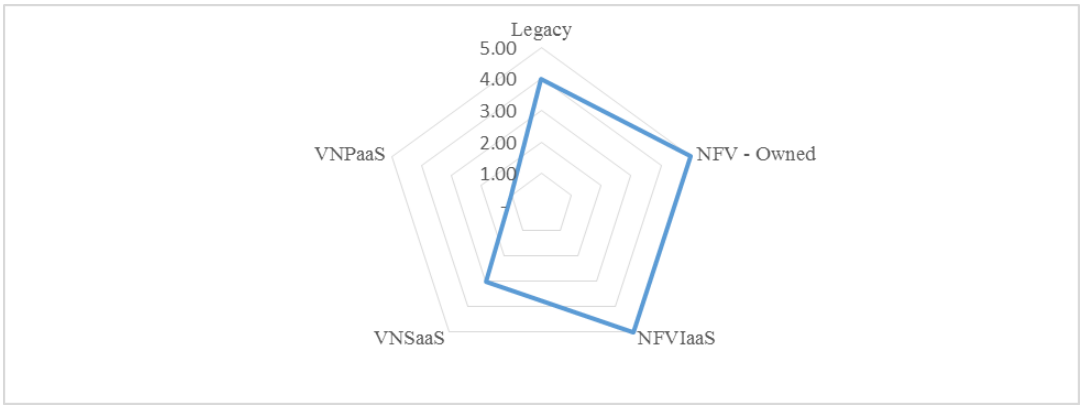


Figure 25. Models' rating based on reducing time to market for new services.

The model has shorter deployment duration.

Virtualization has benefit over legacy system which derived from avoiding installation of new equipment that improve time to market for new services, owned NFV, NFVIaaS and VNPaaS improve time to market better than legacy system however VNSaaS is the best model to improve it as the requirements of any new service implemented by vendor

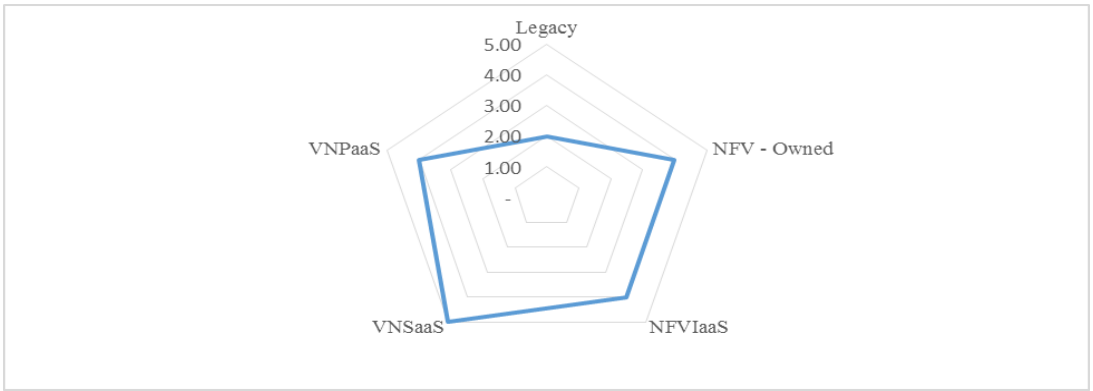


Figure 26. Rating Models' based on shorter deployment duration.

The Model has higher level of horizontal scalability (expansion).

in case of horizontal expansion there are two main items there are two main items that should be taken into consideration the first one is SW license expansion that doesn't differ from model to another, the second one is HW expansion which will differ from model to another in case of legacy system in this case study it has a lot of complexities due to existing limitations and it may be prevented to be entered. Owned NFV has less complexities as the required HW may be found in local market. For cloud solutions NFVIaaS, VNPaaS and VNSaaS HW expansion is vendor responsibility.

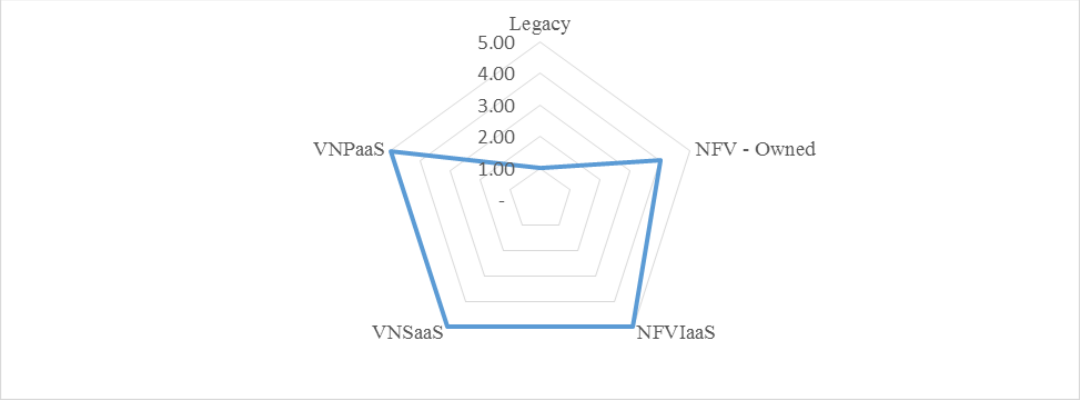


Figure 27. Rating Models' based on horizontal scalability.

The model supports new technologies trends and development.

New technologies almost have new requirements. In legacy system these requirements represented in new legacy unites and SW so it will maximize time to market and reduce value proposition due to long delivered time for legacy units and long implementation time. However this can be reduced in NFV system case as the delivery time and implementation time are less. For cloud solutions it is easier to deploy new technologies on vendor HW

for both NFVIaaS and VNPaaS. Although value proposition and time to market for new technologies are optimized in case of VNSaaS model.

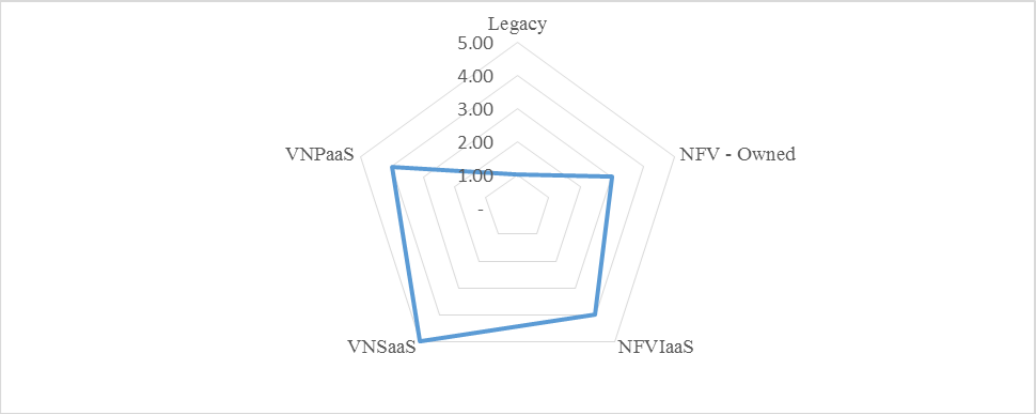


Figure 28. Rating models based on supporting new technologies trends and development.

The model supports platform openness and APIs.

Legacy system is rigid so any new application requires new units and platforms thus it doesn't support open platforms .However for owned NFV and NFVIaaS these models support open platform so it's easily to deploy applications on its platform with minimum SW requirements.

VNPaaS also support platform openness but it still restricted by vendor as platform fails under vendor control so to do changes on platform a confirmation from vendor should be taken also for VNSaaS which depends on application rental from vendor so operator can't do any modification on it

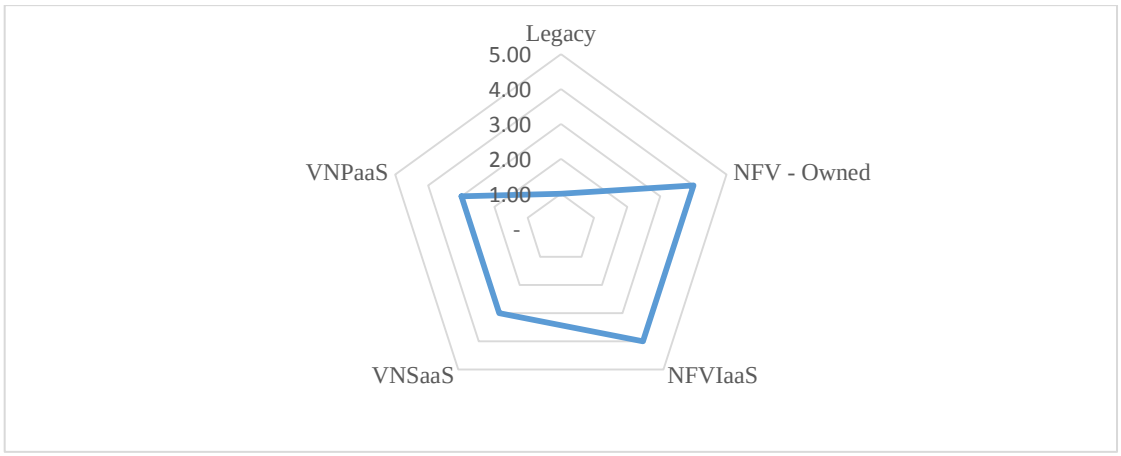


Figure 29. Models' rating based on supporting platform openness and APIs.

The model optimizes supply chain issues.

Supply chain represents all activates , resources and information to produce a products or services , comparing between owned NFV and legacy system , owned NFV optimizes supply chain by reducing number of resources and activities (such as installing HW). However cloud solutions have been optimized supply chain more than owned NFV as VNSaaS is best model for supply chain optimization.

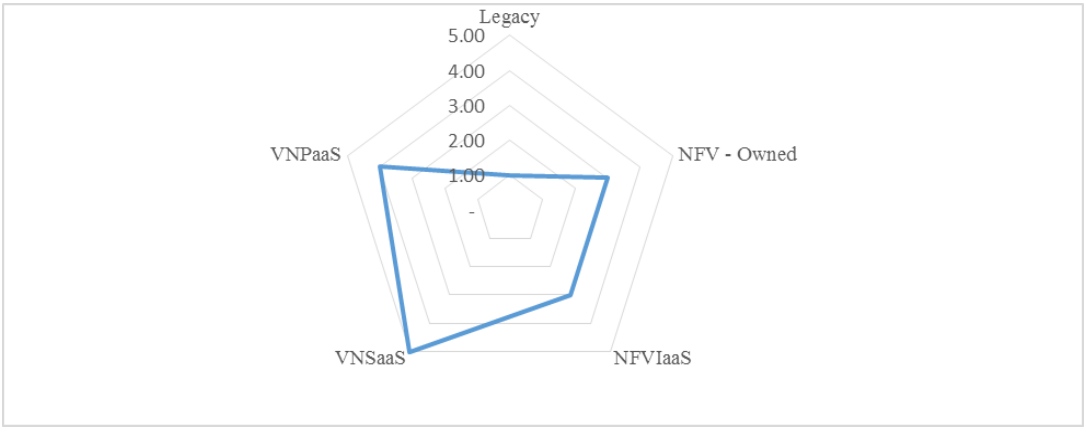


Figure 30. Models' rating based on optimizing supply chain issues

7.3.3 Quality

The Model support efficient SLA model.

SLA model efficiency depends on many factors such as number of vendors and vendor control on operator system these are main two terms that should taking into consideration as these terms increase SLA model efficiency decreases, this can be guaranteed with legacy and owned NFV systems, in cloud solutions that can't be guaranteed and the probability of having efficient SLA model will decrease as vendor control increase.

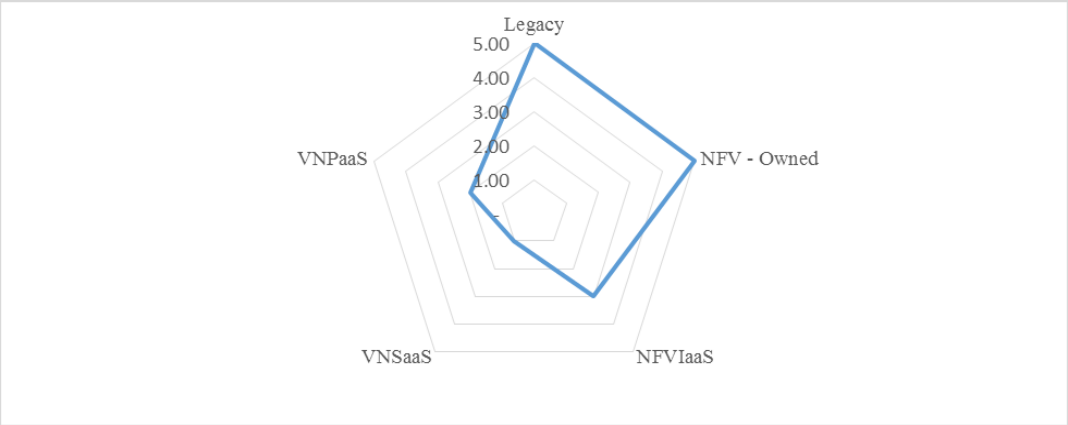


Figure 31. Models' rate for efficient SLA model.

The Model has less interoperability issues (Compatibility of standards, and SW upgrades that makes service chain workable).

In virtualization case (owned NFV, NFVIaaS and VNPaaS) network topology can be dynamically reconfigured so it is compatible of standards, and SW upgrades that makes service chain smoother, for legacy system it may require new HW for SW upgrade, for VNSaaS this is vendor responsibility.

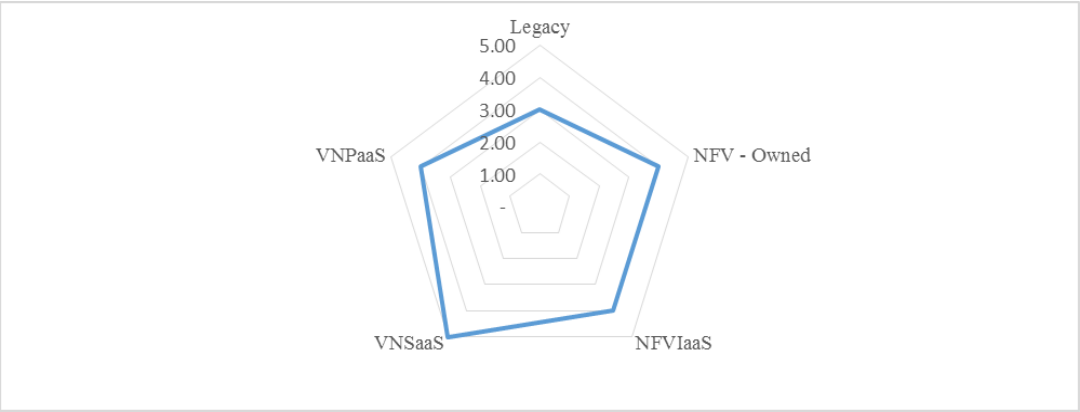


Figure 32. Models 'rate for less interoperability issues.

The Model support higher service availability for end customer (B2B, B2C).

For legacy system and owned NFV both have better guarantee service availability for end customer more than other models due to operator control on its systems so any problem can be monitored by operator however availability issues that are related to HW, virtualized systems are standard systems thus HW issues is easier to deal with more than legacy system however cloud solutions are not guaranteed in terms of service availability and tracking network problems.

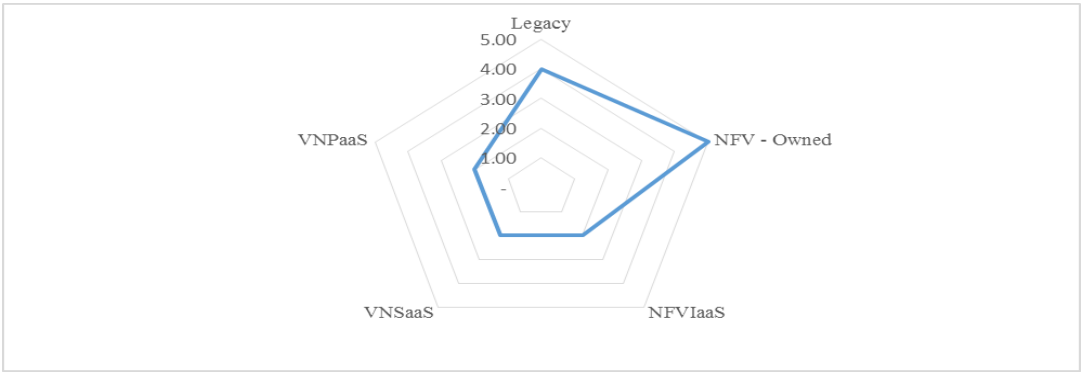


Figure 33. Rating for higher service availability for end customer.

The Model provides higher service capabilities and higher service control.

Legacy system and owned NFV have a higher service control than cloud models as the operator has full control on both systems, for service model service control differs according to vendor control level on the system it increases when vendor level decreases so the level of control in NFVIaaS is the highest than VNPaaS, Finally VNSaaS has the lowest level of control.

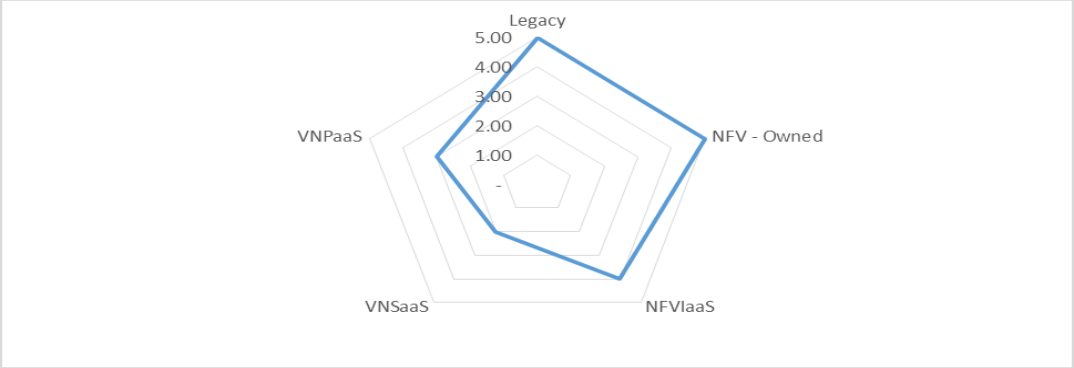


Figure 34. Models' rate for service capabilities and higher service control.

The Model provides application stability.

On application layer legacy system achieves the highest rate of application stability as each unit is dedicated to do special functions, then owned NFV system and NFVIaaS have less rate comparing with legacy system as the function stability can’t be guarantee to level of legacy system, then VNPaaS as platform which controlled by vendor may affect function stability . VNSaaS has the lowest rate as application stability controlled by vendor.

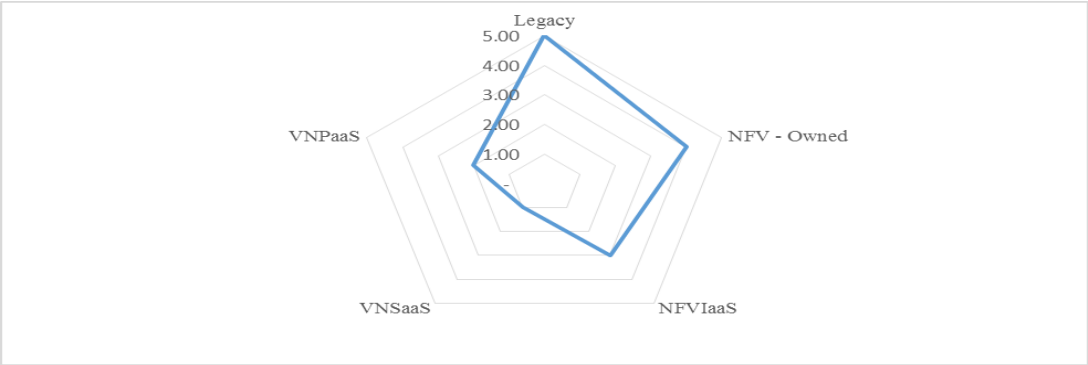


Figure 35. Models' rate for application stability.

The Model supports DR (Geo Redundancy) strategy.

For disaster recovery, geo redundancy mitigation strategy is followed to reduce the impact of disasters. Applying this strategy on legacy system is complex due to required integration and its costly solution while EPC model has less complexities and cost. While for cloud solutions it is a vendor response.

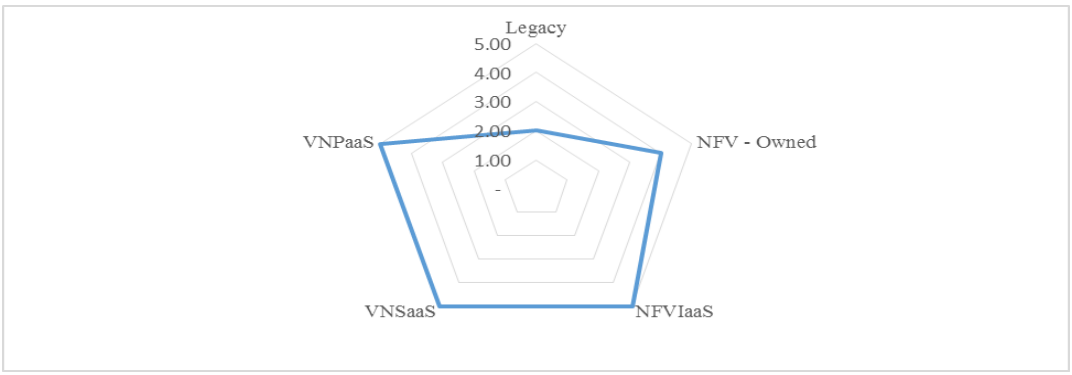


Figure 36. Models' rate for supports DR (Geo Redundancy) strategy.

The model supports data management and analytics purposes to adapt for required service level.

Data management and analytics are important for operators as they are core of market needs and behaviors for legacy system doesn’t support data

management and retention. However, it could be turned out to make it supportable for data management through new architect that integrate these legacy system with proper data management system which classify as complex producer. For owned NFV and NFVIaaS it's easy to support data management through virtual machine itself by suitable capacity planning between data retention and other functions so there is no need for complex integration with other systems. For remaining cloud solutions data retention is a feature that operator could rent from vendor which its cost increase according to data volume and retention time.

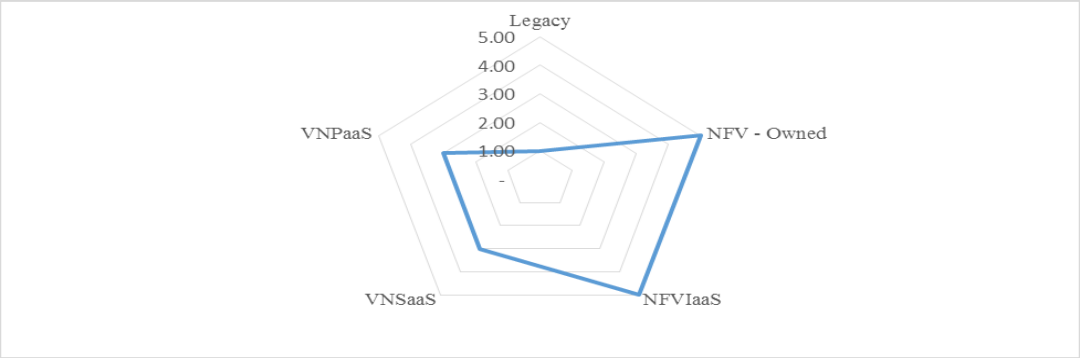


Figure 37. Models' rate for supporting data management and analytics purposes.

The models supports effective service chain flow (a chain must not have any performance bottleneck, or single point of failure).

To have an effective supply chain, the model shouldn't have a performance bottleneck or single point of failure. Thus it is important to take into consideration when selecting a model that chosen model shouldn't have bottleneck and single point of failure as these are major causes from service drop , for legacy system every single unit in the system if it doesn't have a redundancy it performs a bottleneck in high demand and single point of

failure for whole system if it has critical role, for owned NFV ,NFVIaaS and VNPaaS proper capacity planning could eliminate these threats however for VNSaaS this should be agreed with vendor with suitable SLA however it can't be NFVIaaS and VNPaaS such as owned NFV however HW is under vendor control which should be agreed with vendor for redundancy plan.

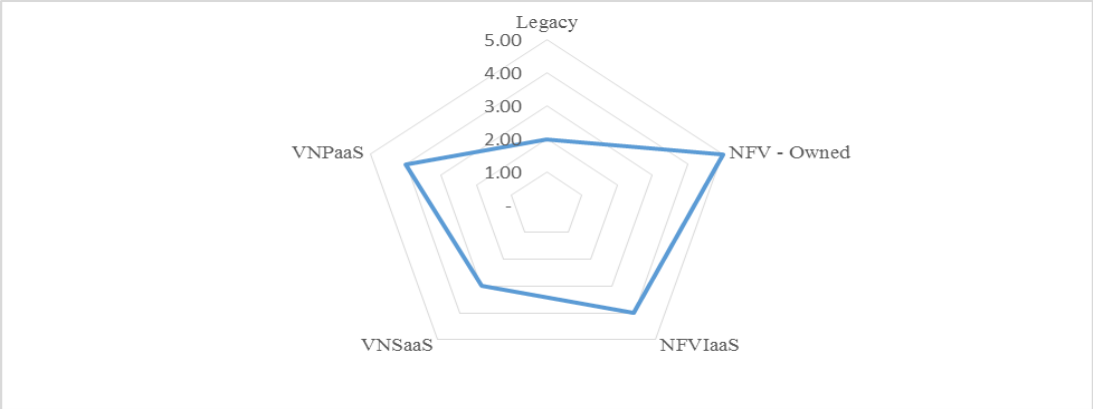


Figure 38. Models' rate in supporting effective service chain flow.

The Model supports efficient troubleshooting time.

Legacy system is dedicated HW. Thus troubleshooting is easier as mostly every unit has a special types of problems. However unified HW in NFVIaaS and owned NFV makes troubleshooting on HW level more complex. Comparing mentioned models with VNPaaS it can be discerned that troubleshooting become harder as the responsibility will be divided between operator and vendor. Finally troubleshooting in VNSaaS model is vendor responsibility which so the efficiency can't be guaranteed.

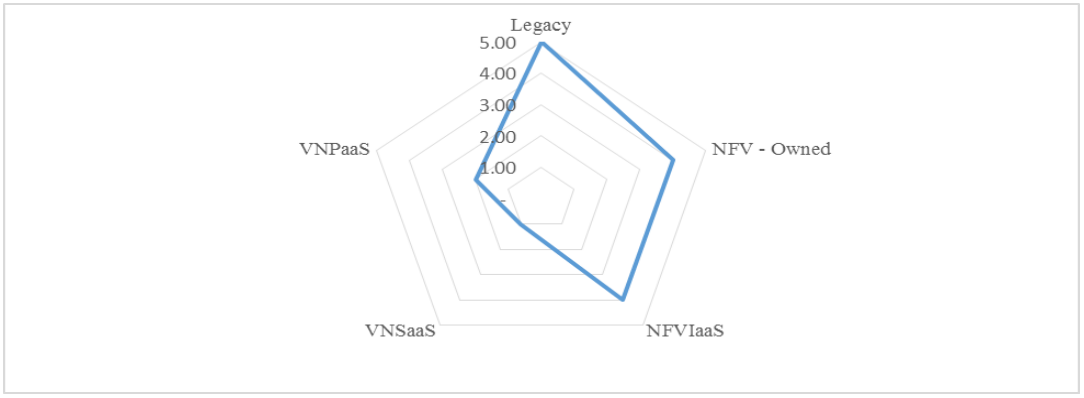


Figure 39. Models' rate inefficient troubleshooting time.

7.3.4 Security

The model has robustness against security threats.

Security one of the challenges that face operators in any system implementation, however security threats can't be disposed of, operators may reduce its impact or prevent some of them but absolutely not all security threats. Legacy system is the most robustness model against these threats then owned NFV system as the control of infrastructure and SW under operator control which reduces the danger comparing with remaining models which are over cloud so the probability of threats are higher than legacy and owned NFV systems.

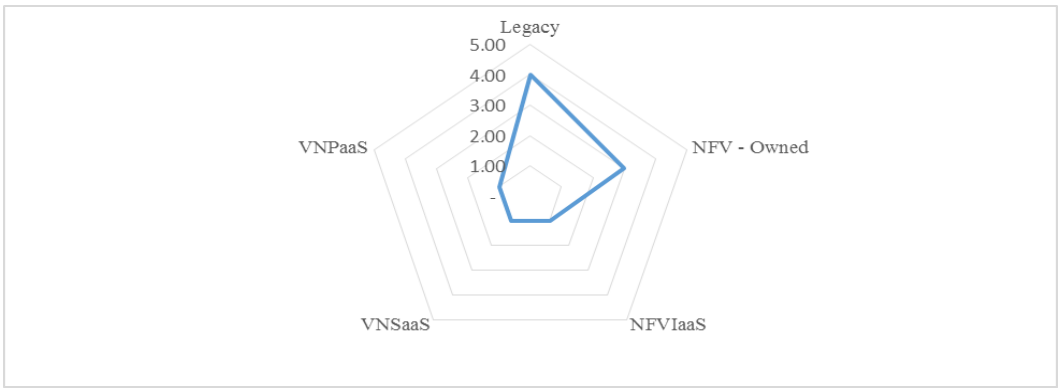


Figure 40. Models' rating in robustness against security threats.

7.3.5 Value Proposition

The Model Support Business vision to extend value proposition beyond access connectivity by new services (B2B, B2C).

For enabling new B2B, B2C services such as big data, advance M2M, digital services, efficient model is required to handle traffic and demand on high QoS, respectful time to market, and support high service scalability and flexibility. Thus VNSaaS, VNPaaS and are the most models that support such value proposition due to high scalability and high service development flexibility, the owned NFV and NFVIaaS come to be the second choice for this KPI, while the legacy has a lot of development and scalability restrictions that make it not good enough to support company value proposition cycle efficiently

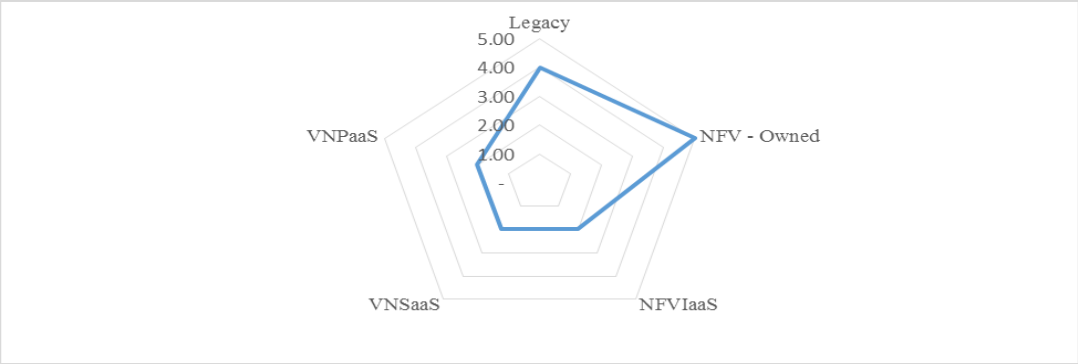


Figure 41. Models' rating in Supporting Business vision to extend value proposition.

The Model improves R&D and innovation effectiveness.

Legacy unites are black box that can’t be develop on it except by its manufacturer so there is no way to do innovation or R&D on the unit. However owned NFV and NFVIaaS are flexible models that enable

operators to do R&D and innovation on it. However VNPaaS allow operator to do innovation and research on data and application layers. Meanwhile VNSaaS model doesn't allow operator to do innovation or researches.

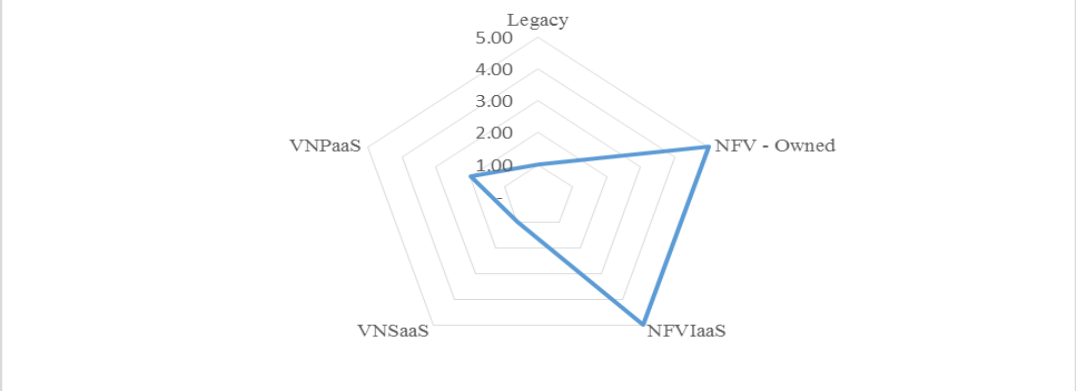


Figure 42. Models' rating in R&D improvement and innovation effectiveness.

7.3.6 Management Complexity

The model has less requirement for expertise in HW operation management.

legacy system has the most complex HW requirements specially if the network has more than one vendor then HW integration will be more complex, however owned NFV has less complex requirements than complex , for other models the hardware will be under vendor control so HW requirements complexity will be managed by vendor.

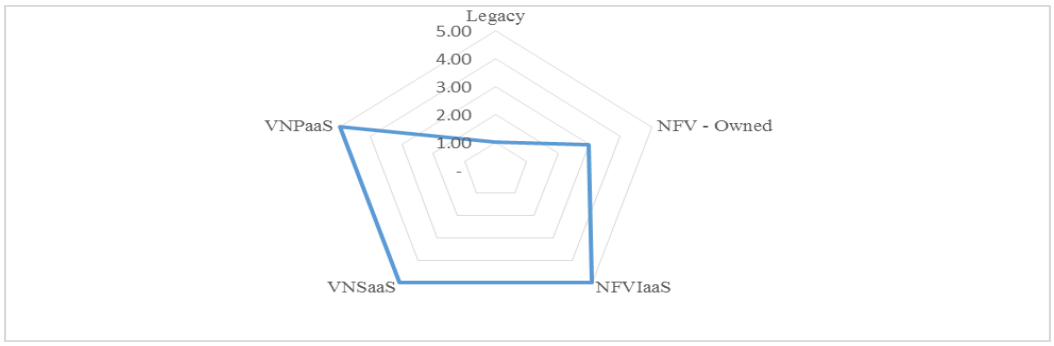


Figure 43. Models' rating according to low requirement for expertise in HW operation management.

The model has less requirement for expertise in SW operation management.

For SW requirements it will not differs from these models except VNSaaS which has the less SW requirements , as virtualization principle is to replace dedicated HW with same SW.

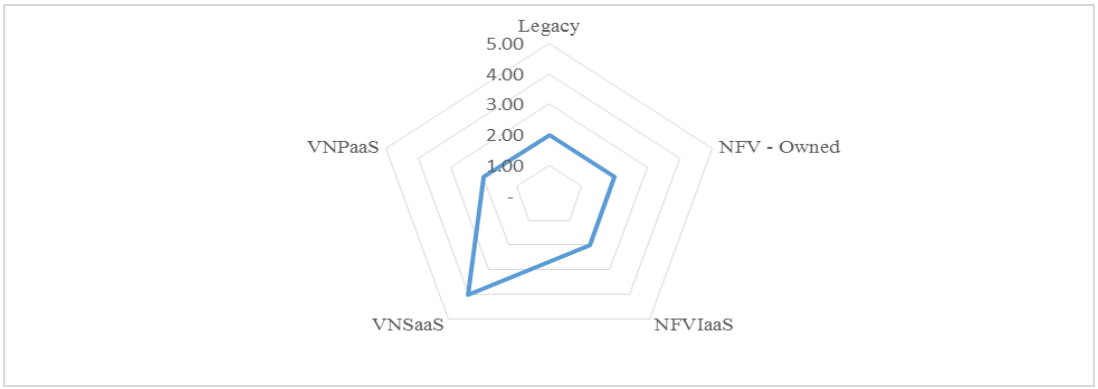


Figure 44. Models' rating according to requirement for expertise in SW operation management.

The model support to reduce the number of required staff to handle operations.

For legacy system the team needed to deal with network is the biggest which should include HW specialist ,administrators and SW specialists for

each legacy node for owned NFV the network team should include SW specialists for each SW, HW specialists and administrators for existing servers which minimize number of team . For NFVIaaS SW specialists for each SW and administrators however HW will be managed by vendor, VNPaaS SW specialists are needed for each SW however administrators and HW specialists are managed by vendor, for VNSaaS SW, HW and administrators will be managed by vendor.

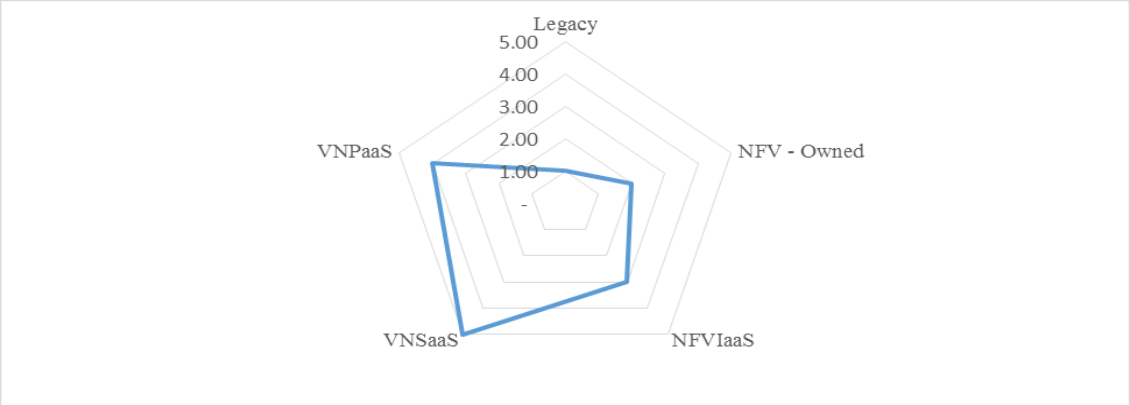


Figure 45. Models' rating according to required operation staff reduction.

7.3.7 Operation Complexity

The model has less complexities in implementation & integration.

Operator will has almost no complexities in implementation and integration with VNSaaS model as this is vendor responsibility, VNPaaS follows VNSaaS as it has low complexity in terms of implementation, operator and vendor are responsible of implementation and integration however vendor has the bulk of the responsibility. then Owned NFV and NFVIaaS has the same rate almost as operator is responsible for implementation and integration however they will be less than owned legacy system which is

the most complex model because of legacy unites has integration and implementation complexities.

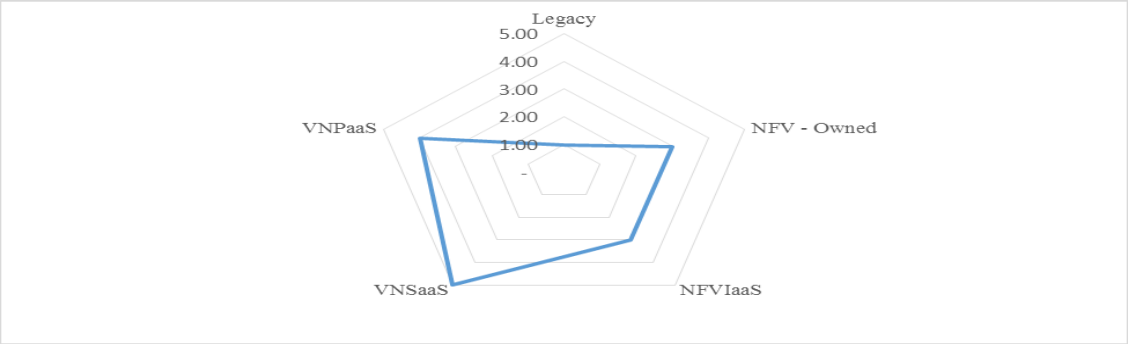


Figure 46. Models' rating according to reduction in complexities in implementation & integration.

The model has less complexities in running operation.

Virtualization technologies is used to reduce legacy system operations complexities by seizing it to amalgamate different network legacy equipment onto standard high volume servers, for legacy, it has the most operation complexities then owned NFV, NFVIaaS, VNPaaS, VNSaaS respectively.

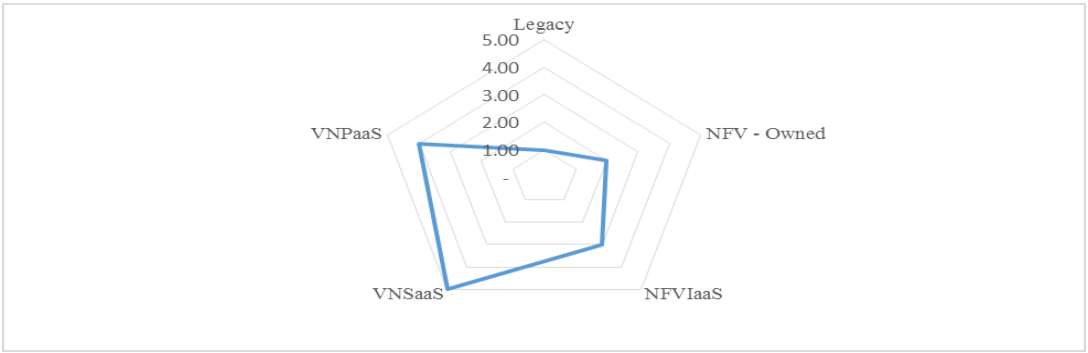


Figure 47. Models' rating according to reduction in complexities in running operation.

7.3.8 Regulation Issues

The model is more effective according to existing regulation policies

Telecom market in Palestine has special case of occupation regulation existing as it limits equipment entry so it is hard to enter telecom legacy units ,otherwise NFV servers are easier to enter and they may exist in local market , for cloud solution there is no HW is needed to it will be easier.

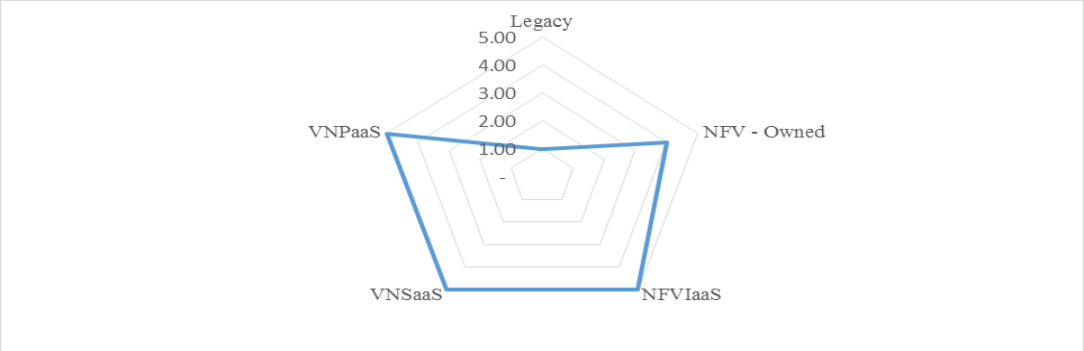


Figure 48. Models' rating for effectivness according to existing regulation policies.

7.3.9 Regulation polices

The model is highly recommended by regulation.

Telecom regulation in Palestine focus on customer data privacy as it is prevent share customers' data with unauthorized access. So it is preferred to keep customers' data within operator .as in the cloud models, data is easier to be accessed by unauthorized people.

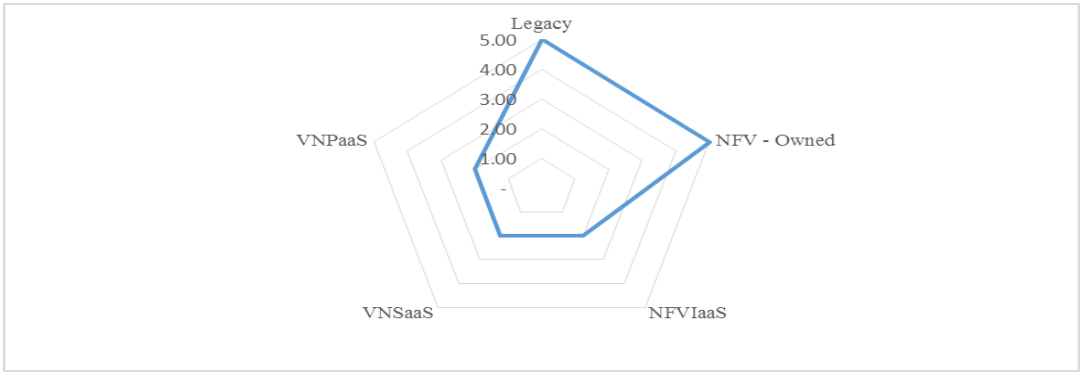


Figure 49. Models' rating based on regulation recommendation.

Chapter Eight
Results

8.1 Results

After consolidating the inputs from all engines and process the scores generated from each engine, the final results as Table 4:

Table 4. KPIs weight and models rate.

KPIs	KPIs Weight[7]	Rate[8]				
		Legacy	NFV - Owned	NFVIaaS	VNSaaS	VNPaaS
Reduce CapEx	0.07	1.00	2.00	3.00	5.00	5.00
Reduce OpEx	0.14	4.00	5.00	4.00	1.00	2.00
Improve QoS (Availability, SLA, Service Redundancy ...etc.)	0.13	3.56	4.56	3.78	2.56	3.00
Minimize the Security Threats	0.10	4.00	3.00	1.00	1.00	1.00
Optimize the time to Market	0.10	1.67	3.83	4.17	4.33	3.50
Products and Services Value Proposition	0.10	1.00	3.50	3.50	1.75	2.00
Reduce Management Complexity	0.07	1.20	2.80	3.40	4.40	3.60
Reduce Operation Complexity	0.11	1.00	2.50	3.00	5.00	4.00
Overcome the Regulation issues	0.12	1.00	4.00	5.00	5.00	5.00
Follow Regulation policies and Recommendation	0.06	5.00	5.00	2.00	2.00	2.00

The result is aligned with each engine outputs and analysis observations, since the readiness stage the company showed high interest in reducing the OpEx and enhance operation excellence, and OpEx reduction come at the

[7] Weight for each KPI= (60%*weight from operation) + (25%* weight from business) + (15%* weight from transformation trigger) (percentage referring to Ooredoo Palestine Standard).
[8] Rate for each model is an average for model rate related to all KPIs.

top of main KPIs that company targeting to achieve in the KPIs weight engine, and owned NFV model (vEPC) has the highest rate for OpEx reduction the cost engine and the highest average score cross all KPIs in the Models rating engine with average score of 3.7 as shown in Table 5.

Thus, the NFV owned Model (vEPC) is the recommended solution for Ooredoo Palestine case according to the analysis engines and company inputs.

Table 5. Models final results[9].

Model	Legacy	NFV - Owned	NFVIaaS	VNSaaS	VNPaaS
Result	**2.4**	**3.7**	**3.4**	**3.1**	**3.1**

9 Result for each model =KPIs Wight* model rate

Chapter Nine

Conclusion and Recommendations

9.1 Conclusion

The NFV and virtualization has significant trend in the telecom and information security industry transformation, and a lot of researches and applications has been developed to utilize the NFV concepts in the telecom field. Further, the telecom operators are suffering from profit decline and mainly at the emerging markets, therefore, the mobile operators and telecom OEMs start develop their strategies to gain from NFV and virtualization trends to reduce the operational cost, and optimize service value chain by scale up service portfolio horizontally and vertically, in order to enhance or at least maintain the same level of business profitability in challenging telecom markets.

Nowadays, the data services are the main revenue stream for mobile operators and it's called "Cash Cow" but at same time the demand on data services has significant impacts on operation cost that mobile operators aim to optimize to achieve the targeted profitability level. Thus, the mobile operators and data network vendors searched out to deploy an optimized data network solutions within their networks that support business innovation and objectives but moreover improve data services cost expenditures, their search ended by applying NFV and virtualization models and concepts on mobile data core network to achieve business excellence targets. The virtualization and EPC – NFV models are part of

this applications that deployed by different mobile operator in different models based on each operator case.

However, this research develops a mathematical model that can support any mobile operator and mainly at emerging markets to evaluate their readiness to transform from legacy EPC model to virtualized NFV model, and to understand which NFV models that recommended for their data core network (EPC) case based on an inputs that user can enter about their company strategy objectives, the most KPIs the company aims to achieve, and the cost drivers for their specific case.

Ooredoo Palestine has been selected as case study of emerging markets with tough competition and low telecom business profitability. Ooredoo Palestine has recently launched 3G services with modernized network and aims to optimize operational excellence and deploy effective data core solution that can scale up with market demand on time and in flexible manner that overcome the market regulation and political restrictions on supply chain. Ooredoo Palestine seeks to have a solution that enhance and enable new revenue streams with significant cost optimization and mainly operational expenditures to improve company profitability.

The developed model were applied on Ooredoo Palestine case and the model showed that Ooredoo Palestine has good level of readiness to start data core (EPC) transformation toward virtualization. Moreover, the model has generated a recommendation to deploy the owned NFV model (vEPC) for Ooredoo Palestine data core network case since it’s the most model that

fit with Ooredoo Palestine strategic interests and market factors. The owned NFV model has the best OpEx reduction rate with high level of operational excellence among all business KPIs.

This research discussed business models related to EPC system that can be applied on emerging market and showed pros and cons related to defined key performance indicators for each model, so operators can judge the suitable model for their cases. Also the spotlight was focused on virtualized EPC models as virtualization is new technology trend that improved its efficiency in optimizing operation, management and commercial performance.

9.2 Recommendations

Based on analysis result, the recommended model is owned NFV .However network virtualization is new technology that has not implemented in Palestinian operators before so there are many risks related to technology nature should be addressed. Table 6 identifies risks related to vEPC.

Table 6. Risk identification.[10]

Risk Identification				`		
Rank	Risk description	Perceived cause	Risk category	Impact	Probability	Inherent Risk Severity
1	Service drop	Due to disconnection through implementation and integration stage	Internal	5	80%	20
3	Availability of virtualization Experts and Consultants	Difficulty to find virtualization experts willing to work in Palestine based on a short term contract	External	3	100%	15
4	Delay and additional cost in the project	The concept may be changed in later stages according vendors systems	External/ Internal	3	60%	9
1	Security threats	Virtual mobile networks become vulnerable to a number of security threats.	External	5	80%	20

A residual risk assessment was done to have mitigation plans that could reduce the impact of risk or the probability of risk.

[10] Impact of Risk has a range of :1→(neglected impact), 2→(low impact), 3→ (medium impact), 4→(high impact), 5→ (extreme impact)

Table *7* shows the mitigation plan for identified risks.

Table 7. Residual Risk Assessment.

		Residual Risk Assessment			
Rank	Risk description	Residual Risk Assessment	impact	Probability	Residual Risk Severity
1	Service drop	to do virtualization in multi stages starting with less important nodes that has less impact on customers services	5	60%	15
3	Availability of virtualization Experts and Consultants	Accelerate the training plan for WM team. Utilize the Oreedo group mobility to bring experts.	3	60%	9
4	Delay and additional cost in the project	N/A	3	60%	9
1	Security threats	some of existing threats can be leveraged using some available mitigation techniques, security expert should be available to minimize effect of these threats	3	60%	12

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Appendix

Appendix A

Readiness Survey

1. EPC_NFV Ambition				
The operator has a clear and compelling EPC_NFV case for change	◯1	◯2	◯3	◯4
The operator has qualified EPC_NFV risks and opportunities on the value chain and impact on its differentiating capabilities and business definition	◯1	◯2	◯3	◯4
The operator has defined its EPC_NFV strategy: company vision of what business definition it should evolve towards and which core businesses	◯1	◯2	◯3	◯4
The operator has a clear strategy on how to leverage EPC_NFV technologies to improve its competitiveness in its core access business (technologies & behaviors include in particular: SDN architectures,M2M, vedio streaming, big data and OTT)	◯1	◯2	◯3	◯4
The operator has a clear strategy on how to deploy its business model to the changing telecom value chain and how to compete/cooperate with EPC_NFV challengers	◯1	◯2	◯3	◯4
3.Product and services				
EPC_NFV technology is fully embedded into the value propositions	◯1	◯2	◯3	◯4
We leverage EPC_NFV technologies to anticipate and address customer needs proactively and in real time	◯1	◯2	◯3	◯4
The company leverages EPC_NFV to extend value proposition beyond access connectivity value propositions	◯1	◯2	◯3	◯4
is it recommend that EPC is the most important core part to virtulize it				
yes				
NO				

challenges in preparing your business for EPC -NFV				
Systems/technology				
People/organization				
Employee skillsets				
Process reengineering				
Security				
Impacted by move to EPC NFV				
NOC Real Time Operations				
Field Service Operations				
Traffic Analysis and Load Management				
Network Resource and Infrastructure Planning				
Network Budgeting and Investment				
Network Procurement				
Network Services Planning				
New User Service Creation				
Network Service Deployment				
Service Marketing				
Service Management				
Administrative Data Center Operations				
Company				
Other				
How much these statements represents company view of EPC-NFV advantage?				

EPC-NFV is critical to the success of company success				
EPC-NFV strategy will give company a competitive advantage				
EPC-NFV is best to be had to the company but no more than other strategies				
How much do you think EPC-NFV will enable following technologies ?				
3G				
	◯ 1	◯ 2	◯ 3	◯ 4
4G				
	◯ 1	◯ 2	◯ 3	◯ 4
Big data				
	◯ 1	◯ 2	◯ 3	◯ 4
5G				
	◯ 1	◯ 2	◯ 3	◯ 4
IOT				
	◯ 1	◯ 2	◯ 3	◯ 4
OTT				
	◯ 1	◯ 2	◯ 3	◯ 4
How much following statement support EPC-NFV				
EPC-NVF will minimize the effects of illegal competition came from other operators such as Cellcom IL				
	◯ 1	◯ 2	◯ 3	◯ 4
EPC-NFV will enhance QoS				
	◯ 1	◯ 2	◯ 3	◯ 4
EPC-NFV will enhance time to market				
	◯ 1	◯ 2	◯ 3	◯ 4
EPC-NFV impacts the security in negative way	◯ 1	◯ 2	◯ 3	◯ 4

Appendix B
Models Rating Related to KPIs

Related KPI	Statement	1	2	3	4	5	Models
Cost	Model support OPEX Reduction				4		Legacy
						5	NFV - Owned
					4		NFVIaaS
		1					NFVSaaS
			2				NFVPaaS
Cost	Model Support CAPEX Reduction	1					Legacy
			2				NFV - Owned
				3			NFVIaaS
						5	NFVSaaS
						5	NFVPaaS
Value Proposition	The Model Support Business vision to extend value proposition beyond access connectivity by new services (B2B, B2C)	1					Legacy
						5	NFV - Owned
				3			NFVIaaS
				3			NFVSaaS
						5	NFVPaaS
Time to MKT	The model support reducing time to market for new services				4		Legacy
						5	NFV - Owned
						5	NFVIaaS
				3			NFVSaaS
		1					NFVPaaS
Security	The model has robustness against security threats				4		Legacy
				3			NFV - Owned
		1					NFVIaaS
		1					NFVSaaS
		1					NFVPaaS
Complexity	The model has less complexities in implementation & integration	1					Legacy
				3			NFV - Owned
				3			NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Time to MKT	The model has shorter deployment duration		2				Legacy
					4		NFV - Owned
					4		NFVIaaS
						5	NFVSaaS
					4		NFVPaaS

Related KPI	Statement	1	2	3	4	5	Models
complexity/time to MKT	The model optimizes supply chain issues	1					Legacy
				3			NFV - Owned
				3			NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Value proposition	The Model improves R&D and innovation effectiveness	1					Legacy
						5	NFV - Owned
						5	NFVIaaS
		1					NFVSaaS
			2				NFVPaaS
Quality	The models supports effective service chain flow (a chain must not have any performance bottleneck, or single point of failure)		2				Legacy
					4		NFV - Owned
					4		NFVIaaS
				3			NFVSaaS
				3			NFVPaaS
Quality	The Model supports efficient troubleshooting time					5	Legacy
					4		NFV - Owned
				4			NFVIaaS
		1					NFVSaaS
			2				NFVPaaS
Regulatory	The model is highly recommended by regulation					5	Legacy
						5	NFV - Owned
			2				NFVIaaS
			2				NFVSaaS
			2				NFVPaaS
Regulatory	The model is more effective according to existing regulation policies	1					Legacy
					4		NFV - Owned
						5	NFVIaaS
						5	NFVSaaS
						5	NFVPaaS

Related KPI	Statement	1	2	3	4	5	Models
Complexity	The model has less complexities in running operation	1					Legacy
			2				NFV - Owned
				3			NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Complexity	The model has less requirement for expertise in HW operation management	1					Legacy
				3			NFV - Owned
						5	NFVIaaS
						5	NFVSaaS
						5	NFVPaaS
Complexity	The model has less requirement for expertise in SW operation management		2				Legacy
			2				NFV - Owned
			2				NFVIaaS
					4		NFVSaaS
			2				NFVPaaS
Complexity	The model support to reduce the number of required staff to handle operations	1					Legacy
			2				NFV - Owned
				3			NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Quality	The Model support efficient SLA model					5	Legacy
						5	NFV - Owned
				3			NFVIaaS
		1					NFVSaaS
			2				NFVPaaS
Quality	The Model has less interoperability issues (comptability of standards, and SW upgrades that makes service chain workable)			3			Legacy
					4		NFV - Owned
					4		NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Quality	The Model support higher service availability for end customer (B2B, B2C)				4		Legacy
						5	NFV - Owned
			2				NFVIaaS
			2				NFVSaaS
			2				NFVPaaS

Related KPI	Statement	1	2	3	4	5	Models
Quality	The Model provides higher service capabilities and higher service control					5	Legacy
						5	NFV - Owned
					4		NFVIaaS
			2				NFVSaaS
				3			NFVPaaS
Time to MKT	The Model has higher level of horizontal scalability (expansion)	1					Legacy
					4		NFV - Owned
						5	NFVIaaS
						5	NFVSaaS
						5	NFVPaaS
Quality	The Model provides application stability					5	Legacy
					4		NFV - Owned
				3			NFVIaaS
		1					NFVSaaS
			2				NFVPaaS
Quality	The Model supports DR (Geo Redundancy) strategy		2				Legacy
					4		NFV - Owned
						5	NFVIaaS
						5	NFVSaaS
						5	NFVPaaS
Value Proposition/time to MKT	The model supports new technologies trends and development	1					Legacy
				3			NFV - Owned
					4		NFVIaaS
						5	NFVSaaS
					4		NFVPaaS
Quality	The model supports data management and analytics purposes to adapt for required service level	1					Legacy
						5	NFV - Owned
						5	NFVIaaS
				3			NFVSaaS
				3			NFVPaaS
Value Proposition/Time to MKT/ Complexity	The model supports platform openness and APIs	1					Legacy
					4		NFV - Owned
					4		NFVIaaS
				3			NFVSaaS
				3			NFVPaaS

Appendix C

Cost Input

	HSS							
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
input								
HW Units	2	2	2	2	2	2	4	4
forecasted needed software license(SAS)	180,000	270,000	364,500	437,400	459,270	482,234	506,345	531,662
HW unit price	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
SW unit price	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
# of Skilled SW Employees	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
#of Skilled HW Specialist	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0
Skilled Employee Salary (+package)	24,000	24,240	24,482	24,727	24,974	25,224	25,476	25,731
Avg Logistic Cost Assumption/unit	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Spare Parts Cost	12%	0%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Ave Power Consumption Cost /node	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vendor HW Discount	10%	10%	10%	10%	10%	10%	10%	10%
SW Upgrade	-	-	0.06	-	0.06	-	0.06	-
Infra investment Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
SW Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
Plate form sharing factor								
rate for NPV	0.12	0	0	0	0	0	0	0
rent percentage increment	-	0	0	0	0	0	0	0
additional OPEX								
other cost 1								
additional costs CAPEX								
other cost 1								

	MME							
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
input								
HW Units	2	2	2	2	2	2	4	4
forecasted needed software licenses(SAS)	180,000	315,000	488,250	634,725	729,934	839,424	965,337	########
HW unit price	422,000	422,000	422,000	422,000	422,000	422,000	422,000	422,000
SW unit price	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
# of Skilled SW Employees	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
#of Skilled HW Specialist	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0
Skilled Employee Salary (+package)	24,000	24,240	24,482	24,727	24,974	25,224	25,476	25,731
Avg Logistic Cost Assumption/unit	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Spare Parts Cost	12%	0%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Ave Power Consumption Cost /node	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vendor HW Discount	10%	10%	10%	10%	10%	10%	10%	10%
SW Upgrade	-	-	0.10	-	0.10	-	0.10	-
Infra investment Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
SW Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
Plate form sharing factor								
rate for NPV	0	0	0	0	0	0	0	0
rent percentage increment	-	-	-	-	-	-	-	-
additional OPEX								
other cost 1								
additional CAPEX								
other cost 1								

	PCRF							
	1	2	3	4	5	6	7	8
input								
HW Units	2	2	2	2	2	2	2	2
forecasted needed software license(SAS)	180,000	270,000	418,500	544,050	625,658	719,506	827,432	951,547
HW unit price	185,000	185,000	185,000	185,000	185,000	185,000	185,000	185,000
SW unit price	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
# of Skilled SW Employees	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
#of Skilled HW Specialist	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Skilled Employee Salary (+package)	24,000	24,240	24,482	24,727	24,974	25,224	25,476	25,731
Avg Logistic Cost Assumption/unit	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
spare Parts Cost	12%	12%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Ave Power Consumption Cost /node	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vendor HW Discount	10%	10%	10%	10%	10%	10%	10%	10%
SW Upgrade	-	-	0.08	-	0.08	-	0.08	-
Infra investment Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
SW Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
Plate form sharing factor								
rate for NPV	0	0	0	0	0	0	0	0
rent percentage increment	-	-	-	-	-	-	-	-
additional OPEX								
other cost 1								
additional CAPEX								
other cost 1								

	SGW							
	1	2	3	4	5	6	7	8
input								
HW Units	2	2	2	2	2	2	4	4
forecasted needed software license(SAS)	180,000	333,000	516,150	670,995	771,644	887,391	########	########
HW unit price	511,000	511,000	511,000	511,000	511,000	511,000	511,000	511,000
SW unit price	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
# of Skilled SW Employees	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0
#of Skilled HW Specialist	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0
Skilled Employee Salary (+package)	24,000	24,240	24,482	24,727	24,974	25,224	25,476	25,731
Avg Logistic Cost Assumption/unit	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
spare Parts Cost	12%	0%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Ave Power Consumption Cost /node	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vendor HW Discount	10%	10%	10%	10%	10%	10%	10%	10%
SW Upgrade	-	-	0.10	-	0.10	-	0.10	-
Infra investment Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
SW Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
Plate form sharing factor								
rate for NPV	0	0	0	0	0	0	0	0
rent percentage increment	-	-	-	-	-	-	-	-
additional cost for uncommon costs OPEX								
other cost 1								
additional cost for uncommon costs CAPEX								
other cost 1								

	EPG							
	1	2	3	4	5	6	7	8
input								
HW Units	2	2	2	2	2	2	4	4
forecasted needed software license(SAS)	180,000	333,000	516,150	670,995	771,644	887,391	########	########
HW unit price	########	########	########	########	########	########	########	########
SW unit price	3.43	3.43	3.43	3.43	3.43	3.43	3.43	3.43
# of Skilled SW Employees	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
#of Skilled HW Specialist	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0
Skilled Employee Salary (+package)	24,000	24,240	24,482	24,727	24,974	25,224	25,476	25,731
Avg Logistic Cost Assumption/unit	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
spare Parts Cost	12%	0%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	145,000	145,000	145,000	145,000	145,000	145,000	145,000	145,000
Ave Power Consumption Cost /node	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Vendor HW Discount	10%	10%	10%	10%	10%	10%	10%	10%
SW Upgrade	-	-	0.15	-	0.15	-	0.15	-
Infra investment Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
SW Sharing Factor	0%	0%	0%	0%	0%	0%	0%	0%
Plate form sharing factor								
rate for NPV	0	0	0	0	0	0	0	0
rent percentage increment	-	-	-	-	-	-	-	-
additional OPEX								
other cost 1								
additional CAPEX								
other cost 1								

	1	2	3	4	5	6	7	8
input								
HW Units	60	60	60	60	60	60	90	90
forcasted needed software licance(SAS)	-	-	-	-	-	-	-	-
HW unit price	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
SW unit price	1.50	1.50	1.50	1.50	1.50	1.50	1.30	1.30
# of Skilled SW Employees	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
#of Skilled HW Specialist	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0
Skilled Employee Salary (+package)	18,000	18,180	18,362	18,545	18,731	18,918	19,107	19,298
Avg Logistic Cost Assumption/unit	500	500	500	500	500	500	500	500
Sapre Parts Cost	12%	0%	0%	12%	0%	0%	12%	0%
SW Support cost	12%	12%	12%	12%	12%	12%	12%	12%
HW Support cost	5%	5%	5%	5%	5%	5%	5%	5%
Professional Cost	10%	10%	10%	10%	10%	10%	10%	10%
Hosting Location Cost	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Managed services	-	-	-	-	-	-	-	-
Ave Power Consumption Cost /node	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Vendor HW Discount	0%	0%	0%	0%	0%	0%	0%	0%
SW Upgrade	-	-	-	-	-	-	-	-
Infra investment Sharing Factor	60%	60%	60%	60%	60%	60%	60%	60%
SW Sharing Factor	50%	50%	50%	50%	50%	50%	50%	50%
Plate form sharing factor	50%	50%	50%	50%	50%	50%	50%	50%
rate for NPV	0	0	0	0	0	0	0	0
rent percentage increment	-	-	-	-	-	-	-	-
additional OPEX								
other cost 1								
additional CAPEX								

Appendix D

Cost Index

Financial Analysis NFVIaaS:		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
EBITDA NPV		652,139	663,045	669,762	672,284	674,812	677,348	847,045	850,333
Net		(1,332,633)	(669,588)	0	0	0	-	0	0
		1.00	1.0	1.00	0.00	0.0	0.00	0.00	0.0
Payback period (Years, Months)	3.000	36							
NPV EBITDA	3,883,579								
Initial investment	1,984,772								
npv	1,898,807								

Financial Analysis NFVIaaS:		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
EBITDA NPV		1,909,637	2,248,190	2,918,988	3,344,883	3,613,624	3,921,318	4,590,225	4,995,389
Net		(5,167,229)	(2,919,038)	(50)	0	0	-	0	0
		1.00	1.0	1.00	0.00	0.0	0.00	0.00	0.0
Payback period (Years, Months)	3.000	36							
NPV EBITDA	17,731,566								
Initial investment	7,076,865								
npv	10,654,701								

Financial Analysis NFVPaaS:		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
EBITDA NPV		2,814,653	2,531,291	2,271,582	2,034,195	1,821,642	1,631,322	1,770,039	1,584,980
Net		(4,802,885)	(2,271,593)	(12)	0	0	0	0	0
		1.00	1.0	1.00	0.00	0.0	0.00	0.00	0.0
Payback period (Years, Months)	3.000	36							
NPV EBITDA	16,459,704								
Initial investment	7,617,538								
npv	8,842,166								

Owned NFV EPC Total TCO over 8 years	35,966,704
Total OPEX owned NFV EPC	14,950,470
Total CAPEX owned NFV EPC	21,016,234

Total TCO over 8 years	48,215,878
Total OPEX Legecy EPC	18,118,648
Total CAPEX Legecy EPC	30,097,230

Appendix E

KPIs Weight

projects distribution weight	Category	Statement	KPIs	1	2	3	4	5
0.25	Business Strategy	The company NFV Strategy aims to achieve ? (based on priority)	Reduce CAPEX					
			Reduce OPEX					
			Improve QoS (Availability, SLA, Service Redundancy ...etc.)					
			Minimize the Security Threats					
			Optimize the time to Market					
			Products and Services Value Proposition					
			Reduce Management Complexity					
			Reduce Operation Complexity					
			Overcome the Regulation issues					
			Follow Regulation policies and Recommendation					
0.15	Transformation Trigger	The main trigger for Transformation to vEPC/NFV	Reduce CAPEX					
			Reduce OPEX					
			Improve QoS (Availability, SLA, Service Redundancy ...etc.)					
			Minimize the Security Threats					
			Optimize the time to Market					
			Products and Services Value Proposition					
			Reduce Management Complexity					
			Reduce Operation Complexity					
			Overcome the Regulation issues					
			Follow Regulation policies and Recommendation					
0.6	Technical Deployment Approach	In Technical deployment approach is considering Goals with priorities	Reduce CAPEX					
			Reduce OPEX					
			Improve QoS (Availability, SLA, Service Redundancy .etc.)					
			Minimize the Security Threats					
			Optimize the time to Market					
			Products and Services Value Proposition					
			Reduce Management Complexity					
			Reduce Operation Complexity					
			Overcome the Regulation issues					
			Follow Regulation policies and Recommendation					

جامعة النجاح الوطنية

كلية الدراسات العليا

تطبيق الرزم المتطورة الافتراضية في مشغلي الاتصالات المتنقلة الفلسطينية

اعداد

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اشراف

د. سائد طربية

د. شادي عطا الله

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الادارة الهندسية، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس- فلسطين.

2019

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الملخص

الشبكة الوظيفية الافتراضية هي تكنولوجيا تم اقتراحها من أجل تخفيف أثر تدني الربح في قطاع الاتصالات العالمي. وبناءا عليه فان الشبكة الوظيفية الافتراضية هي اتجاه جديد للتغلب على تحديات البنية التحية المطلوبة لتقديم خدمات جديدة وادارة النمو السريع في الطلب على خدمات البيانات.

الهدف الاساسي من هذه الدراسة هي التفريق بين نماذج الخدمات الافتراضية وهي: الشبكة الوظيفية الافتراضية للبنية التحتية كخدمة والشبكة الوظيفية الافتراضية كبرنامج والشبكة الوظيفية الافتراضية كبرمجيات. وبين النماذج الأولية وهي الشبكة الوظيفية الافتراضية المملوكة والنظام المخصص القديم من خلال تقييم الجوانب التشغيلية والادارية والتجارية المتعلقة بالنماذج. أيضا تقديم توصيات شاملة للحالة الدراسية من حيث أفضل نموذج يمكن تطبيقه على الرمة الأساسية المتطورة .

في هذه الدراسة تم تطوير نموذج رياضي على عدة مراحل الذي ينتهي بنموذج الرمة الأساسية المتطورة الموصي به للمشغل بناءا على معطيات المشغل. أول مرحلة تتمثل في تقييم مدى استعداد المشغل من أجل التحويل إلى نظام الرمة الأساسية المتطورة الافتراضية، ثم يتم الانتقال إلى المرحلة الثانية وهي تقييم مؤشرات الأداء الرئيسية والتي تخضع للمنظور التجاري والتقني والتحويلي، بحيث أن تقييم المؤشرات سوف يختلف من مشغل إلى اخر بناءا على أولويات الشركة وأهدافها التجارية. بعد ذلك تأتي المرحلة الثالثة والتي تتمثل في تقيم نماذج الرمة الأساسية

المتطورة لكل مؤشر أداء رئيسي وهذه المرحلة تنقسم إلى قسمين رئيسين: القسم الأول هو المعدل النوعي بحيث يتم تقيم نماذج الرمة الأساسية المتطورة بناءا على دراسات وتجربة الخبراء والتغذية الراجعة من المزودين ، القسم الثاني هو المعدل الكمي والذي يتعلق بمؤشرات الاداء الرئيسية المالية والتي تتمثل في قيمة الاستثمار بالإضافة إلى المصاريف التشغيلية لكل نموذج من نماذج الرمة الاساسية المتطورة .لذلك المعدل الكمي سوف يختلف بين مشغل واخر بناءا على المعطيات المالية لكل مشغل.

بعد أن يتم تطبيق النموذج الرياضي على المشغل فان نتائج النرياضي تتلخص في: النتيجة الأولى هي مدى استعداد المشغل للانتقال إلى الشبكة الوظيفية المطورة بحيث يعتمد بشكل كامل على قرار المشغل، بناءا على معطيات تقييم الاستعداد للانتقال إلى الشبكة الوظيفية الافتراضية أو عدم الانتقال بالإضافة إلى تحديد المخاطر المتعلقة في استراتيجية الانتقال إلى الشبكة الوظيفية. المخرج الثاني من النموذج الرياضي هو نموذج الرمة الاساسية المتطورة الموصي به للمشغل بناءا على تقيم مؤشرات الأداء الرئيسية والمعطيات المالية للمشغل.

هذه الدراسة تركز على سوق الاتصالات الفلسطيني حيث أن فلسطين تعد دولة نامية خاضعة للاحتلال وعوائقه في مختلف القطاعات. حيث أن قطاع الاتصالات واحدة من هذه المجالات التي تعاني من القوانين المفروضة من الاحتلال. في هذا السياق هذه الدراسة طبقت على أوريدو فلسطين احدى المشغلات الخلوية الفلسطينية بحيث أن اوريدو فلسطين تقدم خدماتها في سوق يوجد فيه منافسة قوية بين المشغلات الفلسطينية بالإضافة إلى المنافسة الغير قانونية المفروضة من المشغلات الخرى مثل مشغل سيليكوم الاسرائيلي ومشغل أورنج الاسرائيلي.

أظهرت نتائج الدراسة أن أوريدو فلسطين على استعداد عالي من أجل التحويل نحو النظام الافتراضي، بحيث أن استراتيجية النظام الافتراضي هي استراتيجية رئيسية يمكن من خلالها التقليل من تأثير التحديات التي تواجه المشغلات الفلسطينية. بالإضافة إلى ذلك أظهرت النتائج ان نموذج الحزمة الأساسية المتطورة الموصي بتطبيقه في أوريدو فلسطين هو الشبكة الوظيفية الافتراضية

المملوكة، كما عرضت الدراسة تحليل كامل المخاطر الاستراتيجية للنظام الافتراضي المتعلقة بالحالة الدراسية لأوريدو فلسطين.