

SDN and NFV: The Game-changing Impact 2017-2023

February 2018



2201 World Trade Center, Brigade Gateway Campus, Malleswaram, Bengaluru India – 560055

Phone: +1 973 973 541 9600, +91 80 6793 5731 Email: marketing@insight-corp.com

www.insight-corp.com

The contents of this study represent our analysis of the information generally available to the public or released by responsible individuals in the companies mentioned. It does not contain information provided in confidence by our clients. Since much of the information in the study is based on a variety of sources that we deem to be reliable, including subjective estimates and analyst opinion, Techgradient and Insight Research does not guarantee the accuracy of the contents and assumes no liability for inaccurate source materials.

Copyright © 2018 by Techgradient.

All Rights Reserved. Insight Research Corporation is a trademark of Techgradient.

Printed in India. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, prior to written permission of the publisher.

Table of Contents

1.	Executive Summary.....	1
1.1	Salient quantitative observations.....	2
1.2	Drivers for SDN and NFV	4
1.2.1	Service agility.....	5
1.2.2	Centralized control	5
1.2.3	Enhanced reliability.....	6
1.2.4	Software-driven approach	6
1.2.5	Cost savings.....	7
1.2.6	Vendor neutral hardware	7
1.2.7	Optimal utilization of resources	8
1.2.8	Flexibility in network design.....	8
1.2.9	Benign effect on capital and operating expenditure	8
1.2.10	Ownership of feature-rich services.....	8
1.2.11	Takeaways for telcos from SDN and NFV.....	9
2.	Software-Defined Networking	11
2.1	Introduction and Evolution.....	11
2.1.1	Role played by Industry consortiums	12
2.2	SDN Architecture.....	13
2.2.1	Application layer	13
2.2.2	Control Layer	14
2.2.2.1	The OpenDaylight (ODL) SDN Platform	14
2.2.2.2	The OpenContrail SDN Platform	15
2.2.2.2.1	OpenContrail architecture	16
2.2.2.2.2	Compute node	17
2.2.2.2.3	Control Plane.....	17
2.2.2.2.4	Configuration nodes	17

Table of Contents

2.2.2.2.5	Analytics Node.....	17
2.2.2.2.6	REST APIs.....	18
2.2.2.2.7	OpenStack	18
2.2.2.3	Open Network Operating System (ONOS)	18
2.2.3	Infrastructure Layer	19
2.3	SDN interfaces	19
2.3.1	Northbound interfaces	20
2.3.1.1	REST	21
2.3.1.2	Java.....	21
2.3.2	Southbound interfaces	21
2.3.2.1	OpenFlow.....	21
2.3.2.2	OVSDB	22
2.3.2.3	NETCONF	22
2.3.2.4	YANG and Others	23
2.4	SDN Use-cases.....	23
2.5	SDN Use-Case: CORD	24
2.5.1	Traction among telcos	25
2.6	SDN Use-Case: Service Delivery/Fulfilment, excluding BoD.....	25
2.6.1	Nuage Networks Virtualized Services Platform (VSP).....	26
2.7	SDN Use-Case: NaaS/ BoD	27
2.7.1	Infinera Xceed	28
2.7.2	HPE Carrier SDN	28
2.8	SDN Use-Case: Mobile Network Virtualization/ Network slicing	29
2.8.1	Affirmed Networks Virtual Slice Selection Function (vSSF)	29
2.9	SDN Use-Case: SD-WAN	30
2.9.1	Versa SD-WAN Solution	30
2.9.1.1	Versa Director	30
2.9.1.2	Flex VNF.....	30

Table of Contents

2.9.2	NEC/Netcracker SDN Controllers.....	31
2.10	SDN Use-Case: Service function chaining.....	31
2.10.1	Benu Virtual Service Edge (VSE).....	31
2.11	Multifunction SDN Controller	32
2.11.1	Adva Ensemble.....	32
3.	Network Functions Virtualization	35
3.1	Introduction and evolution	35
3.2	Role played by European Telecommunications Standards Institute (ETSI)	36
3.2.1	Other noteworthy contributors.....	37
3.3	NFV architecture.....	38
3.3.1	VNFs/NFVi.....	38
3.3.2	Managing NFVi Performance	39
3.3.2.1	Offloading	39
3.3.3	Hypervisors – vSphere, KVM and others.....	40
3.3.4	DPDK – Accelerating the processors	40
3.3.5	Fast Data Input / Output (FD.io) – an Able Ally for DPDK.....	41
3.3.6	Containers – Contrarians to VMs.....	42
3.3.7	VNFs	42
3.3.8	MANO.....	43
3.3.8.1	Virtualized Infrastructure Manager (VIM).....	44
3.3.8.1.1	Kubernetes	44
3.3.8.2	VNF Manager (VNFM).....	45
3.3.8.3	NFV Orchestrator (NFVO)	45
3.3.8.4	Open Network Application Platform (ONAP)	45
3.3.8.4.1	Backstory of Open-O	47
3.3.8.4.2	Backstory of ECOMP	47
3.3.8.5	Lifecycle Services Orchestrator – The contrarian MANO	48
3.3.9	Parallels with server virtualization	48

Table of Contents

3.4	VNF Use-Cases.....	49
3.5	VNF Use-Case: Switching and Routing VNFs.....	50
3.5.1	vADC/vLB/vWOC VNF - NFWare vADC.....	50
3.5.2	vADC/vLB/vWOC VNF - Avi-Vantage Platform.....	51
3.5.3	vRouter/vCGNAT/vIPSec/vVPN VNF - Juniper vMX CG Router.....	51
3.5.4	vRouter/vCGNAT/vIPSec/vVPN VNF - NFWare vCGNAT.....	51
3.5.5	vSwitch VNF - Huawei CE 1800 vSwitch.....	52
3.6	VNF Use-Case: Core WAN VNFs.....	52
3.6.1	vIMS/vCSC/vPCRF VNF - Metaswitch Clearwater IMS Core.....	52
3.6.2	vBBU/vRAN/xRAN VNF - Altiostar vRAN.....	53
3.6.3	vEPC/vVoLTE VNF - Nokia VoLTE.....	54
3.6.4	vEPC/vVoLTE VNF - Samsung AdaptiV.....	54
3.6.5	vEPC/vVoLTE VNF - Affirmed Networks MCC.....	54
3.7	VNF Use-Case: Interface and gateway VNFs.....	55
3.7.1	vAMS/vSBC/vWebRTC GW VNF - Metaswitch Perimeta SBC.....	55
3.7.2	vCPE/vSG VNF - Huawei USG6000V vSG.....	56
3.7.3	vWAG VNF - Genband NFV (vWAG).....	56
3.8	VNF Use-Case: Standard and security device VNFs.....	56
3.8.1	vDNS VNF - Infoblox Virtual Secure DNS.....	56
3.8.2	vFirewall VNF - Fortinet FortiGate VM.....	57
3.8.3	vFirewall VNF - Fortinet FortiGate VMX.....	57
3.8.4	vIPSec/vVPN VNF - 6WIND Turbo IPsec.....	57
3.9	VNF Use-Case: IP application VNFs.....	58
3.9.1	vIM VNF - Genband NFV (vIM).....	58
3.9.2	vVoIP VNF – Mushroom Networks VoIP Armor.....	58
3.10	VNF Use-Case: Testing VNFs.....	58
3.10.1	vProbe/vTA VNF - Netrounds vTA.....	59
3.10.2	vProbe/vTA VNF - Enea Qosmos NFV Probe.....	59

Table of Contents

3.10.3	vProbe/vTA VNF - Ixia IxNetwork VE	60
4.	Solution Provider Profiles	61
4.1	Overview of the Market	61
4.1.1	Possibilities of rebranding existing solutions as NFV and SDN-enabled.....	61
4.1.2	Non-agreement about the extent of mutual dependence of SDN and NFV	62
4.1.3	Addressing challenges associated with NFV and SDN	62
4.2	Organization Categories	62
4.2.1	Equipment vendors.....	62
4.2.2	Independent software vendors	63
4.2.3	Semiconductor specialists	63
4.2.4	OS and firmware specialists	63
4.2.5	Niche solution developers	63
4.3	Company Profiles.....	64
4.4	6WIND.....	64
4.4.1	SDN and NFV initiatives.....	64
4.4.1.1	6WINDGate	65
4.4.1.2	6WIND Virtual Accelerator	66
4.4.1.3	6WIND Turbo Router	66
4.4.1.4	6WIND Turbo IPsec.....	66
4.4.2	Analysis.....	66
4.5	Adva.....	67
4.5.1	SDN and NFV initiatives.....	67
4.5.1.1	Ensemble	67
4.5.2	Analysis.....	67
4.6	Affirmed Networks	68
4.6.1	SDN and NFV initiatives.....	68
4.6.1.1	Affirmed Networks Mobile Content Cloud (MCC)	68
4.6.1.2	Affirmed Networks Virtual Slice Selection Function (vSSF)	69

Table of Contents

4.6.2	Analysis.....	69
4.7	Altiosstar.....	69
4.7.1	SDN and NFV initiatives.....	69
4.7.1.1	Altiosstar vRAN	69
4.7.2	Analysis.....	69
4.8	Amdocs	70
4.8.1	SDN and NFV initiatives.....	70
4.8.1.1	Network Cloud Service Orchestrator (NSCO)	70
4.8.2	Analysis.....	71
4.9	Anuta Networks	72
4.9.1	SDN and NFV initiatives.....	72
4.9.1.1	Anuta NCX.....	72
4.9.2	Analysis.....	72
4.10	Aricent.....	73
4.10.1	SDN and NFV initiatives.....	73
4.10.1.1	VNF Manager.....	73
4.10.2	Analysis.....	74
4.11	Atrinet	74
4.11.1	SDN and NFV initiatives.....	74
4.11.1.1	Atrinet NetACE.....	74
4.11.2	Analysis.....	75
4.12	Atto-Research.....	75
4.12.1	SDN and NFV initiatives.....	75
4.12.1.1	Athene	75
4.12.1.2	OBelle	76
4.12.2	Analysis.....	76
4.13	Avi Networks	76
4.13.1	SDN and NFV initiatives.....	77

Table of Contents

4.13.1.1	Avi-Vantage Platform	77
4.13.2	Analysis	77
4.14	Barefoot Networks	77
4.14.1	SDN and NFV initiatives.....	77
4.14.1.1	Barefoot Tofino	77
4.14.2	Analysis	78
4.15	Benu Networks	78
4.15.1	SDN and NFV initiatives.....	78
4.15.1.1	Benu VSE.....	79
4.15.2	Analysis.....	79
4.16	CA Technologies.....	79
4.16.1	SDN and NFV initiatives.....	79
4.16.1.1	CA Technologies Virtual Network Assurance (VNA).....	79
4.16.2	Analysis.....	80
4.17	Canonical/Ubuntu	80
4.17.1	SDN and NFV initiatives.....	80
4.17.1.1	Canonical OpenStack	80
4.17.2	Analysis.....	81
4.18	Cavium.....	81
4.18.1	SDN and NFV initiatives.....	82
4.18.1.1	ThunderX ARMv8 Processors	82
4.18.1.2	OCTEON TX ARMv8 SoCs.....	82
4.18.1.3	XPliant Programmable SDN Ethernet Switches	82
4.18.1.4	LiquidIO Fully Programmable Network Adapters	83
4.18.1.5	FastLinQ Network Adapters	83
4.18.2	Analysis.....	83
4.19	Cenx	84
4.19.1	SDN and NFV initiatives.....	84

Table of Contents

4.19.1.1	CENX 7.....	84
4.19.2	Analysis.....	84
4.20	Ciena.....	85
4.20.1	SDN and NFV initiatives.....	85
4.20.1.1	Blue Planet SDN/NFV Orchestrator.....	85
4.20.2	Analysis.....	86
4.21	Cisco Systems.....	86
4.21.1	SDN and NFV initiatives.....	87
4.21.1.1	Cisco Adaptive Security Virtual Appliance (ASA v).....	87
4.21.1.2	Cisco Nexus 1000V Virtual Switch.....	87
4.21.1.3	Cisco Cloud Services Router CSR 1000V.....	87
4.21.1.4	Cisco NFV Infrastructure (NFVI).....	88
4.21.1.5	Cisco Application Centric Infrastructure (ACI) – SDN for datacenters.....	89
4.21.1.6	Network Services Orchestrator.....	90
4.21.1.7	Virtual Managed Services (VMS).....	90
4.21.2	Analysis.....	90
4.22	Corsa Technology.....	91
4.22.1	SDN and NFV initiatives.....	91
4.22.1.1	Corsa 10G/100G SDN Switches.....	91
4.22.2	Analysis.....	92
4.23	Cplane.ai.....	92
4.23.1	SDN and NFV initiatives.....	92
4.23.1.1	Multi-Suite Manager (MSM).....	93
4.23.1.2	Overlay Gateway Router (OGR).....	93
4.23.1.3	Dynamic Virtual Networks (DVN).....	93
4.23.2	Analysis.....	93
4.24	Cumulus.....	94
4.24.1	SDN and NFV initiatives.....	94

Table of Contents

4.24.1.1	Cumulus Linux	94
4.24.2	Analysis	96
4.25	Dell EMC	96
4.25.1	SDN and NFV initiatives.....	97
4.25.1.1	Open Networking Switches.....	97
4.25.2	Analysis	97
4.26	Ekinops (OneAccess Networks).....	97
4.26.1	SDN and NFV initiatives.....	98
4.26.1.1	Ekinops OVP.....	98
4.26.2	Analysis	98
4.27	Enea.....	99
4.27.1	SDN and NFV initiatives.....	99
4.27.1.1	Enea NFV Core and Enea NFV Access	99
4.27.1.2	Enea Qosmos NFV Probe.....	100
4.27.2	Analysis	100
4.28	Ericsson	100
4.28.1	SDN and NFV initiatives.....	100
4.28.1.1	Ericsson Cloud SDN	101
4.28.1.2	Ericsson Services SDN.....	102
4.28.1.3	Ericsson Virtual Router	103
4.28.1.4	Ericsson MANO	103
4.28.1.5	Ericsson NFVi Solution.....	103
4.28.2	Analysis	103
4.29	ETSI	104
4.30	F5 Networks	105
4.30.1	SDN and NFV initiatives.....	105
4.30.1.1	Big IP VNF portfolio.....	105
4.30.2	Analysis	106

Table of Contents

4.31	Fortinet.....	107
4.31.1	SDN and NFV initiatives.....	107
4.31.1.1	FortiGate VM.....	107
4.31.1.2	FortiGate VMX.....	107
4.31.2	Analysis.....	107
4.32	HPE.....	107
4.32.1	SDN and NFV initiatives.....	108
4.32.1.1	HPE Carrier SDN.....	108
4.32.1.2	NFV System.....	108
4.32.1.3	Service Director.....	108
4.32.2	Analysis.....	108
4.33	Huawei.....	109
4.33.1	SDN and NFV initiatives.....	109
4.33.1.1	Agile Controller.....	109
4.33.1.2	Huawei CE 1800 Virtual Switch.....	109
4.33.1.3	Huawei USG6000V Virtual Service Gateway.....	109
4.33.1.4	FusionSphere.....	110
4.33.2	Analysis.....	110
4.34	Infinera.....	110
4.34.1	SDN and NFV initiatives.....	110
4.34.1.1	Xceed Software Suite.....	111
4.34.2	Analysis.....	111
4.35	Inocybe.....	111
4.35.1	SDN and NFV initiatives.....	111
4.35.1.1	ONP.....	111
4.35.2	Analysis.....	112
4.36	Infoblox.....	112
4.36.1	SDN and NFV initiatives.....	112

Table of Contents

4.36.1.1	Infoblox Virtual Secure DNS	112
4.36.2	Analysis	112
4.37	Intel	113
4.37.1	SDN and NFV initiatives.....	113
4.37.1.1	Open Network Platform Server	113
4.37.2	Analysis	113
4.38	Ixia	114
4.38.1	SDN and NFV initiatives.....	114
4.38.1.1	IxNetwork VE	114
4.38.1.2	IxLoad VE for L4-L7	114
4.38.1.3	BreakingPoint VE	114
4.38.2	Analysis	115
4.39	Juniper.....	115
4.39.1	SDN and NFV initiatives.....	115
4.39.1.1	Contrail Networking.....	115
4.39.1.2	Contrail Cloud.....	115
4.39.1.3	Contrail Service Orchestration	116
4.39.1.4	vMX Carrier grade router.....	116
4.39.1.5	vSRX Virtual integrated firewall.....	116
4.39.2	Analysis	117
4.40	Linux Foundation	117
4.40.1	SDN and NFV initiatives.....	117
4.40.1.1	OPNFV	118
4.40.2	Analysis	118
4.41	Lumina Networks Inc.....	119
4.41.1	SDN and NFV initiatives.....	119
4.41.1.1	Lumina SDN Controller	119
4.41.1.2	Lumina VNF Manager	119

Table of Contents

4.41.2	Analysis.....	120
4.42	Mushroom Networks.....	120
4.42.1	SDN and NFV initiatives.....	120
4.42.1.1	Truffle Broadband Bonding	120
4.42.2	Analysis.....	120
4.43	Metaswitch Networks.....	121
4.43.1	SDN and NFV initiatives.....	121
4.43.1.1	Metaswitch Perimeta SBC.....	121
4.43.1.2	Metaswitch Clearwater IMS Core	121
4.43.2	Analysis.....	121
4.44	NEC/Netcracker	122
4.44.1	SDN and NFV initiatives.....	122
4.44.1.1	SDN Controllers.....	122
4.44.1.2	NFV MANO.....	122
4.44.1.3	VNFs	122
4.44.1.4	Proposed VNF - Cloud RAN (C-RAN):.....	123
4.44.1.5	Other initiatives	123
4.44.2	Analysis.....	124
4.45	Netronome.....	124
4.45.1	SDN and NFV initiatives.....	124
4.45.1.1	Agilio SmartNICs.....	124
4.45.2	Analysis.....	125
4.46	Netrounds.....	125
4.46.1	SDN and NFV initiatives.....	125
4.46.1.1	Virtual Test Agent (vTA).....	126
4.46.2	Analysis.....	126
4.47	NFWare.....	126
4.47.1	SDN and NFV initiatives.....	126

Table of Contents

4.47.1.1	NFWare vCGNAT	126
4.47.1.2	NFWare Virtual Application Delivery Controller (ADC).....	127
4.47.1.3	vURL-Filtering.....	127
4.47.2	Analysis.....	127
4.48	Nokia.....	127
4.48.1	SDN and NFV initiatives.....	127
4.48.1.1	Nuage Networks Virtualized Services Platform (VSP).....	127
4.48.1.2	Airframe Data Center Solution.....	128
4.48.1.3	CloudBand.....	128
4.48.1.4	Nokia VoLTE.....	128
4.48.2	Analysis.....	129
4.49	NoviFlow	129
4.49.1	SDN and NFV initiatives.....	129
4.49.1.1	NoviSwitch.....	129
4.49.1.2	NoviWare	130
4.49.2	Analysis.....	130
4.50	Oracle.....	130
4.50.1	SDN and NFV initiatives.....	130
4.50.1.1	Communications Network Service Orchestration Solution.....	131
4.50.1.2	Agile IMS Infrastructure for Service Delivery.....	131
4.50.2	Analysis.....	132
4.51	Pluribus	132
4.51.1	SDN and NFV initiatives.....	132
4.51.1.1	Open Netvisor Linux.....	132
4.51.1.2	Adaptive Cloud Fabric	133
4.51.2	Analysis.....	134
4.52	QualiSystems	134
4.52.1	SDN and NFV initiatives.....	134

Table of Contents

4.52.1.1	CloudShell.....	134
4.52.2	Analysis.....	135
4.53	RAD.....	135
4.53.1	SDN and NFV initiatives.....	135
4.53.1.1	vCPE Toolbox.....	135
4.53.2	Analysis.....	136
4.54	Radisys.....	136
4.54.1	SDN and NFV initiatives.....	137
4.54.1.1	Cloud-based NFVi.....	137
4.54.1.2	MediaEngine.....	137
4.54.2	Analysis.....	138
4.55	Red Hat.....	138
4.55.1	SDN and NFV initiatives.....	138
4.55.1.1	Red Hat OpenStack.....	138
4.55.2	Analysis.....	139
4.56	Ribbon Communications.....	139
4.56.1	SDN and NFV initiatives.....	140
4.56.1.1	Sonus VellOS.....	140
4.56.1.2	Sonus SBC Software Lite Edition.....	140
4.56.1.3	Genband VNF Manager.....	140
4.56.1.4	Genband VNFs.....	140
4.56.2	Analysis.....	141
4.57	Samsung.....	141
4.57.1	SDN and NFV initiatives.....	142
4.57.1.1	Samsung AdaptiV.....	142
4.57.2	Analysis.....	142
4.58	Spirent.....	142
4.58.1	SDN and NFV initiatives.....	142

Table of Contents

4.58.1.1	TestCenter Virtual	143
4.58.2	Analysis	143
4.59	Telco Systems	143
4.59.1	SDN and NFV initiatives.....	143
4.59.1.1	Cloud Metro	144
4.59.1.2	NFVTime	144
4.59.2	Analysis	144
4.60	Versa Networks	145
4.60.1	SDN and NFV initiatives.....	145
4.60.1.1	Versa SD-WAN Portfolio	145
4.60.2	Analysis	145
4.61	Veryx Technologies	146
4.61.1	SDN and NFV initiatives.....	146
4.61.1.1	SAMTEST.....	146
4.61.1.2	Virtual Tap (vTAP)	146
4.61.1.3	FlowAnalyzer	147
4.61.1.4	PktBlaster	147
4.61.2	Analysis	147
4.62	VMware	147
4.62.1	SDN and NFV initiatives.....	148
4.62.1.1	VMware NSX.....	148
4.62.2	Analysis	149
4.63	Wind River	150
4.63.1	SDN and NFV initiatives.....	150
4.63.1.1	Titanium Cloud Product Portfolio	150
4.63.2	Analysis	151
5.	Telco Profiles.....	152
5.1	Overview of telco approaches	152

Table of Contents

5.2	Telco profiles	153
5.3	Airtel	153
5.3.1	SDN and NFV initiatives.....	153
5.3.2	Analysis.....	154
5.4	AT&T.....	154
5.4.1	SDN and NFV initiatives.....	154
5.4.2	Analysis.....	156
5.5	BT	156
5.5.1	SDN and NFV initiatives.....	156
5.5.2	Analysis.....	157
5.6	CenturyLink	157
5.6.1	SDN and NFV initiatives.....	158
5.6.2	Analysis.....	159
5.7	China Mobile.....	159
5.7.1	SDN and NFV initiatives.....	159
5.7.2	Analysis.....	160
5.8	China Telecom	161
5.8.1	SDN and NFV initiatives.....	161
5.8.2	Analysis.....	161
5.9	China Unicom	162
5.9.1	SDN and NFV initiatives.....	162
5.9.2	Analysis.....	163
5.10	Deutsche Telekom.....	163
5.10.1	SDN and NFV initiatives.....	163
5.10.2	Analysis.....	164
5.11	Etisalat.....	164
5.11.1	SDN and NFV initiatives.....	165
5.11.2	Analysis.....	165

Table of Contents

5.12	Frontier Communications.....	165
5.12.1	SDN and NFV initiatives.....	165
5.12.2	Analysis.....	166
5.13	Jio	166
5.13.1	SDN and NFV initiatives.....	166
5.13.2	Analysis.....	166
5.14	KDDI.....	167
5.14.1	SDN and NFV initiatives.....	167
5.14.2	Analysis.....	167
5.15	KT	168
5.15.1	SDN and NFV initiatives.....	168
5.15.2	Analysis.....	168
5.16	LG Uplus.....	169
5.16.1	SDN and NFV initiatives.....	169
5.16.2	Analysis.....	169
5.17	NTT Docomo	169
5.17.1	SDN and NFV initiatives.....	170
5.17.2	Analysis.....	171
5.18	Ooredoo.....	171
5.18.1	SDN and NFV initiatives.....	171
5.18.2	Analysis.....	171
5.19	Optus (Singtel Optus).....	172
5.19.1	SDN and NFV initiatives.....	172
5.19.2	Analysis.....	172
5.20	Orange.....	172
5.20.1	SDN and NFV initiatives.....	173
5.20.2	Analysis.....	174
5.21	Saudi Telecom.....	174

Table of Contents

5.21.1	SDN and NFV initiatives.....	174
5.21.2	Analysis.....	174
5.22	Singtel	175
5.22.1	SDN and NFV initiatives.....	175
5.22.2	Analysis.....	175
5.23	SK Telecom.....	176
5.23.1	SDN and NFV initiatives.....	176
5.23.2	Analysis.....	177
5.24	Softbank	177
5.24.1	SDN and NFV initiatives.....	177
5.24.2	Analysis.....	177
5.25	Sprint Corporation.....	178
5.25.1	SDN and NFV initiatives.....	178
5.25.2	Analysis.....	179
5.26	Swisscom	179
5.26.1	SDN and NFV initiatives.....	179
5.26.2	Analysis.....	180
5.27	Telecom Italia	180
5.27.1	SDN and NFV initiatives.....	180
5.27.2	Analysis.....	181
5.28	Telefonica.....	181
5.28.1	SDN and NFV initiatives.....	181
5.28.2	Analysis.....	182
5.29	Telia	182
5.29.1	SDN and NFV initiatives.....	183
5.29.2	Analysis.....	183
5.30	Telkom Indonesia.....	183
5.30.1	SDN and NFV initiatives.....	184

Table of Contents

5.30.2	Analysis.....	184
5.31	Telstra	184
5.31.1	SDN and NFV initiatives.....	184
5.31.2	Analysis.....	185
5.32	Turk Telecom.....	185
5.32.1	SDN and NFV initiatives.....	186
5.32.2	Analysis.....	186
5.33	Turkcell	186
5.33.1	SDN and NFV initiatives.....	187
5.33.2	Analysis.....	187
5.34	Veon VimpelCom	187
5.34.1	SDN and NFV initiatives.....	187
5.34.2	Analysis.....	188
5.35	Verizon.....	188
5.35.1	SDN and NFV initiatives.....	188
5.35.2	Analysis.....	190
5.36	Vodafone.....	190
5.36.1	SDN and NFV initiatives.....	191
5.36.2	Analysis.....	191
6.	Quantitative Forecasts.....	192
6.1	Research Methodology.....	192
6.1.1	SDN Technologies.....	193
6.1.2	NFV Technologies.....	194
6.2	Introduction to forecast taxonomy	194
6.2.1	SDN forecast taxonomy and rationale.....	195
6.2.1.1	Breakdown by solution component	196
6.2.2	NFV forecast taxonomy and rationale.....	197
6.2.2.1	Breakdown by solution component	198

Table of Contents

6.3	User segments	199
6.3.1	Service Providers.....	200
6.3.2	Enterprises and others.....	200
6.4	Geographical Regions	200
6.4.1	North America (NA).....	202
6.4.2	Europe, Middle-East and Africa (EMEA)	202
6.4.3	Asia-Pacific (APAC).....	202
6.4.4	Caribbean and Latin America (CALA)	203
6.5	The SDN market	203
6.5.1	Overview	203
6.5.2	Solution components	204
6.5.2.1	Control hardware.....	204
6.5.2.2	Software	205
6.5.2.3	End-Device Hardware	206
6.5.3	CORD.....	207
6.5.3.1	Definitions and assumptions	207
6.5.3.2	Breakdown by solution components	208
6.5.3.3	Breakdown by user segments	209
6.5.3.4	Breakdown by regional markets.....	209
6.5.4	Service Function Chaining	209
6.5.4.1	Definitions and assumptions	210
6.5.4.2	Breakdown by solution components	210
6.5.4.3	Breakdown by user segments	211
6.5.4.4	Breakdown by regional markets.....	211
6.5.5	SD-WAN.....	212
6.5.5.1	Definitions and assumptions	212
6.5.5.2	Breakdown by solution components	212
6.5.5.3	Breakdown by user segments	213

Table of Contents

6.5.5.4	Breakdown by regional markets.....	214
6.5.6	NaaS/BoD.....	214
6.5.6.1	Definitions and assumptions	214
6.5.6.2	Breakdown by solution components	215
6.5.6.3	Breakdown by user segments	216
6.5.6.4	Breakdown by regional markets.....	216
6.5.7	Network Slicing.....	216
6.5.7.1	Definitions and assumptions	217
6.5.7.2	Breakdown by solution components	217
6.5.7.3	Breakdown by user segments	218
6.5.7.4	Breakdown by regional markets.....	218
6.5.8	Service Delivery and Fulfilment.....	219
6.5.8.1	Definitions and assumptions	219
6.5.8.2	Breakdown by solution components	219
6.5.8.3	Breakdown by user segments	220
6.5.8.4	Breakdown by regional markets.....	221
6.6	The NFV market	221
6.6.1	Overview	222
6.6.2	Solution components	223
6.6.2.1	MANO.....	223
6.6.2.2	NFVi.....	224
6.6.3	vLB, vADC, vWOC	225
6.6.3.1	Definitions and assumptions	225
6.6.3.2	Breakdown by solution components	225
6.6.3.3	Breakdown by user segments	226
6.6.3.4	Breakdown by regional markets.....	227
6.6.4	vRouter, vCGNAT	227
6.6.4.1	Definitions and assumptions	227

Table of Contents

6.6.4.2	Breakdown by solution components	228
6.6.4.3	Breakdown by user segments	229
6.6.4.4	Breakdown by regional markets	229
6.6.5	vSwitch.....	230
6.6.5.1	Definitions and assumptions	230
6.6.5.2	Breakdown by solution components	230
6.6.5.3	Breakdown by user segments	231
6.6.5.4	Breakdown by regional markets.....	231
6.6.6	vIMS, vCSC, vPCRF.....	232
6.6.6.1	Definitions and assumptions	232
6.6.6.2	Breakdown by solution components	232
6.6.6.3	Breakdown by user segments	233
6.6.6.4	Breakdown by regional markets.....	234
6.6.7	vBBU, vRAN, xRAN	234
6.6.7.1	Definitions and assumptions	234
6.6.7.2	Breakdown by solution components	234
6.6.7.3	Breakdown by user segments	236
6.6.7.4	Breakdown by regional markets.....	236
6.6.8	vEPC, vVoLTE	237
6.6.8.1	Definitions and assumptions	237
6.6.8.2	Breakdown by solution components	237
6.6.8.3	Breakdown by user segments	238
6.6.8.4	Breakdown by regional markets.....	238
6.6.9	vAMS, vSBC, vWebRTC GW	239
6.6.9.1	Definitions and assumptions	239
6.6.9.2	Breakdown by solution components	240
6.6.9.3	Breakdown by user segments	241
6.6.9.4	Breakdown by regional markets.....	241

Table of Contents

6.6.10	vCPE, vSG	242
6.6.10.1	Definitions and assumptions	242
6.6.10.2	Breakdown by solution components	242
6.6.10.3	Breakdown by user segments	243
6.6.10.4	Breakdown by regional markets	244
6.6.11	vWAG	244
6.6.11.1	Definitions and assumptions	244
6.6.11.2	Breakdown by solution components	245
6.6.11.3	Breakdown by user segments	246
6.6.11.4	Breakdown by regional markets	246
6.6.12	vDNS	246
6.6.12.1	Definitions and assumptions	247
6.6.12.2	Breakdown by solution components	247
6.6.12.3	Breakdown by user segments	248
6.6.12.4	Breakdown by regional markets	248
6.6.13	vFirewall	248
6.6.13.1	Definitions and assumptions	249
6.6.13.2	Breakdown by solution components	249
6.6.13.3	Breakdown by user segments	250
6.6.13.4	Breakdown by regional markets	250
6.6.14	vIPSec, vVPN	250
6.6.14.1	Definitions and assumptions	251
6.6.14.2	Breakdown by solution components	251
6.6.14.3	Breakdown by user segments	252
6.6.14.4	Breakdown by regional markets	252
6.6.15	vIM	252
6.6.15.1	Definitions and assumptions	253
6.6.15.2	Breakdown by solution components	253

Table of Contents

6.6.15.3	Breakdown by user segments	254
6.6.15.4	Breakdown by regional markets	254
6.6.16	vVoIP	254
6.6.16.1	Definitions and assumptions	255
6.6.16.2	Breakdown by solution components	255
6.6.16.3	Breakdown by user segments	256
6.6.16.4	Breakdown by regional markets	256
6.6.17	vProbe, vTA	256
6.6.17.1	Definitions and assumptions	257
6.6.17.2	Breakdown by solution components	257
6.6.17.3	Breakdown by user segments	258
6.6.17.4	Breakdown by regional markets	258
7.	Glossary and Acronyms	259

Tables and Figures

Table 1-1: Global market for SDN and NFV 2017-2023 (\$ million)2

Figure 1-1: VNF categories and types3

Figure 1-2: Market share of SDN and NFV technologies, by technology4

Figure 1-3: Telco cloud and networking services9

Figure 2-1: SDN Architecture13

Figure 2-2: OpenContrail Architecture16

Figure 2-3: Interfaces to SDN controller20

Figure 2-4: Components of Ensemble family of product32

Figure 3-1: Comparing ECOMP and ETSI MANO48

Figure 4-1: 6WIND Telco cloud and networking services65

Figure 4-2: Amdocs NFV partner ecosystem71

Figure 4-3: Components of Cisco NFVI88

Figure 4-4: Cisco ACI Architecture89

Figure 4-5: Components of Cumulus Linux operating system and their functions95

Figure 4-6: High-level architecture of Ericsson SDN products and solutions101

Figure 4-7: Service chaining flow in Service SDN102

Figure 6-1: SDN technology market forecast taxonomy195

Table 6-1: Global market for SDN; by solution component 2017-2023 (\$ million)196

Figure 6-2: Market share of SDN technology, by solution component196

Figure 6-3: NFV technology market forecast taxonomy197

Table 6-2: Global market for NFV; by solution component 2017-2023 (\$ million)198

Figure 6-4: Market share of NFV technology, by solution component198

Table 6-3: Global market for SDN and NFV; by user segment 2017-2023 (\$ million)199

Figure 6-5: Market share of SDN and NFV technologies, by user segment199

Table 6-4: Global market for SDN and NFV technologies; by regional market 2017-2023 (\$ million)201

Figure 6-6: Market share of SDN and NFV technologies, by geographical region201

Tables and Figures

Figure 6-7: Global market for SDN technologies, by use-case	203
Table 6-5: Global market for SDN Control Hardware; by use-case 2017-2023 (\$ million).....	204
Figure 6-8: Market share of SDN Control Hardware, by use-case	205
Table 6-6: Global market for SDN Software; by use-case 2017-2023 (\$ million).....	205
Figure 6-9: Market share of SDN Software, by use-case	206
Table 6-7: Global market for SDN End-Device Hardware; by use-case 2017-2023 (\$ million).....	206
Figure 6-10: Market share of SDN End-Device Hardware, by use-case	207
Table 6-8: Global market for CORD use-case; by solution component 2017-2023 (\$ million).....	208
Figure 6-11: Market share of CORD use-case, by solution component	208
Table 6-9: Global market for CORD use-case; by user segment 2017-2023 (\$ million)	209
Table 6-10: Global market for CORD use-case; by regional market 2017-2023 (\$ million)	209
Table 6-11: Global market for Service Function Chaining use-case; by solution component 2017-2023 (\$ million)	210
Figure 6-12: Market share of Service Function Chaining use-case, by solution component.....	210
Table 6-12: Global market for Service Function Chaining use-case; by user segment 2017-2023 (\$ million).	211
Table 6-13: Global market for Service Function Chaining use-case; by regional market 2017-2023 (\$ million)	211
Table 6-14: Global market for SD-WAN use-case; by solution component 2017-2023 (\$ million).....	212
Figure 6-13: Market share of SD-WAN use-case, by solution component	213
Table 6-15: Global market for SD-WAN use-case; by user segment 2017-2023 (\$ million).....	213
Table 6-16: Global market for SD-WAN use-case; by regional market 2017-2023 (\$ million)	214
Table 6-17: Global market for NaaS/BoD use-case; by solution component 2017-2023 (\$ million).....	215
Figure 6-14: Market share of NaaS/BoD use-case, by solution component	215
Table 6-18: Global market for NaaS/BoD use-case; by user segment 2017-2023 (\$ million)	216
Table 6-19: Global market for NaaS/BoD use-case; by regional market 2017-2023 (\$ million).....	216
Table 6-20: Global market for network slicing use-case; by solution component 2017-2023 (\$ million) .	217
Figure 6-15: Market share of Network Slicing use-case, by solution component	217
Table 6-21: Global market for network slicing use-case; by user segment 2017-2023 (\$ million).....	218

Tables and Figures

Table 6-22: Global market for network slicing use-case; by regional market 2017-2023 (\$ million).....	218
Table 6-23: Global market for Service Delivery and Fulfilment use-case; by solution component 2017-2023 (\$ million)	219
Figure 6-16: Market share of Service Delivery and Fulfilment use-case, by solution component	220
Table 6-24: Global market for Service Delivery and Fulfilment use-case; by user segment 2017-2023 (\$ million)	220
Table 6-25: Global market for Service Delivery and Fulfilment use-case; by regional market 2017-2023 (\$ million)	221
Figure 6-17: Global market for NFV technologies, by use-case	222
Table 6-26: Global market for MANO; by VNF use-case category 2017-2023 (\$ million).....	223
Figure 6-18: Market share of MANO, by VNF use-case category	223
Table 6-27: Global market for NFVi; by VNF use-case category 2017-2023 (\$ million).....	224
Figure 6-19: Market share of NFVi, by VNF use-case category	224
Table 6-28: Global market for vLB, vADC, vWOC VNFs; by solution component 2017-2023 (\$ million)	225
Figure 6-20: Market share of vLB, vADC, vWOC VNFs, by solution component.....	226
Table 6-29: Global market for vLB, vADC, vWOC VNFs; by user segment 2017-2023 (\$ million).....	226
Table 6-30: Global market for vLB, vADC, vWOC VNFs; by regional market 2017-2023 (\$ million)....	227
Table 6-31: Global market for vRouter, vCGNAT VNFs; by solution component 2017-2023 (\$ million)	228
Figure 6-21: Market share of vRouter, vCGNAT VNFs, by solution component.....	228
Table 6-32: Global market for vRouter, vCGNAT VNFs; by user segment 2017-2023 (\$ million).....	229
Table 6-33: Global market for vRouter, vCGNAT VNFs; by regional market 2017-2023 (\$ million).....	229
Table 6-34: Global market for vSwitch VNF; by solution component 2017-2023 (\$ million)	230
Figure 6-22: Market share of vSwitch VNF, by solution component.....	230
Table 6-35: Global market for vSwitch VNF; by user segment 2017-2023 (\$ million).....	231
Table 6-36: Global market for vSwitch VNF; by regional market 2017-2023 (\$ million).....	231
Table 6-37: Global market for vIMS, vCSC, vPCRF VNFs; by solution component 2017-2023 (\$ million)...	232
Figure 6-23: Market share of vIMS, vCSC, vPCRF VNFs, by solution component	233

Tables and Figures

Table 6-38: Global market for vIMS, vCSC, vPCRF VNFs; by user segment 2017-2023 (\$ million)	233
Table 6-39: Global market for vIMS, vCSC, vPCRF VNFs; by regional market 2017-2023 (\$ million) ..	234
Table 6-40: Global market for vBBU, vRAN, xRAN VNFs; by solution component 2017-2023 (\$ million)	234
Figure 6-24: Market share of vBBU, vRAN, xRAN VNFs, by solution component	235
Table 6-41: Global market for vBBU, vRAN, xRAN VNFs; by user segment 2017-2023 (\$ million).....	236
Table 6-42: Global market for vBBU, vRAN, xRAN VNFs; by regional market 2017-2023 (\$ million) ..	236
Table 6-43: Global market for vEPC, vVoLTE VNFs; by solution component 2017-2023 (\$ million)	237
Figure 6-25: Market share of vEPC, vVoLTE VNFs, by solution component.....	238
Table 6-44: Global market for vEPC, vVoLTE VNFs; by user segment 2017-2023 (\$ million).....	238
Table 6-45: Global market for vEPC, vVoLTE VNFs; by regional market 2017-2023 (\$ million).....	239
Table 6-46: Global market for vAMS, vSBC, vWebRTC GW VNFs; by solution component 2017-2023 (\$ million)	240
Figure 6-26: Market share of vAMS, vSBC, vWebRTC GW VNFs, by solution component	240
Table 6-47: Global market for vAMS, vSBC, vWebRTC GW VNFs; by user segment 2017-2023 (\$ million)	241
Table 6-48: Global market for vAMS, vSBC, vWebRTC GW VNFs; by regional market 2017-2023 (\$ million)	241
Table 6-49: Global market for vCPE, vSG VNFs; by solution component 2017-2023 (\$ million)	242
Figure 6-27: Market share of vCPE, vSG VNFs, by solution component.....	243
Table 6-50: Global market for vCPE, vSG VNFs; by user segment 2017-2023 (\$ million)	243
Table 6-51: Global market for vCPE, vSG VNFs; by regional market 2017-2023 (\$ million).....	244
Table 6-52: Global market for vWAG VNF; by solution component 2017-2023 (\$ million).....	245
Figure 6-28: Market share of vWAG VNF, by solution component	245
Table 6-53: Global market for vWAG VNF; by user segment 2017-2023 (\$ million)	246
Table 6-54: Global market for vWAG VNF; by regional market 2017-2023 (\$ million)	246
Table 6-55: Global market for vDNS VNF; by solution component 2017-2023 (\$ million)	247
Figure 6-29: Market share of vDNS VNF, by solution component.....	247
Table 6-56: Global market for vDNS VNF; by user segment 2017-2023 (\$ million)	248

Tables and Figures

Table 6-57: Global market for vDNS VNF; by regional market 2017-2023 (\$ million).....	248
Table 6-58: Global market for vFirewall VNF; by solution component 2017-2023 (\$ million).....	249
Figure 6-30: Market share of vFirewall VNF, by solution component	249
Table 6-59: Global market for vFirewall VNF; by user segment 2017-2023 (\$ million).....	250
Table 6-60: Global market for vFirewall VNF; by regional market 2017-2023 (\$ million).....	250
Table 6-61: Global market for vIPSec, vVPN VNFs; by solution component 2017-2023 (\$ million).....	251
Figure 6-31: Market share of vIPSec, vVPN VNFs, by solution component.....	251
Table 6-62: Global market for vIPSec, vVPN VNFs; by user segment 2017-2023 (\$ million)	252
Table 6-63: Global market for vIPSec, vVPN VNFs; by regional market 2017-2023 (\$ million).....	252
Table 6-64: Global market for vIM VNF; by solution component 2017-2023 (\$ million)	253
Figure 6-32: Market share of vIM VNF, by solution component.....	253
Table 6-65: Global market for vIM VNF; by user segment 2017-2023 (\$ million).....	254
Table 6-66: Global market for vIM VNF; by regional market 2017-2023 (\$ million).....	254
Table 6-67: Global market for vVoIP VNF; by solution component 2017-2023 (\$ million).....	255
Figure 6-33: Market share of vVoIP VNF, by solution component	255
Table 6-68: Global market for vVoIP VNF; by user segment 2017-2023 (\$ million).....	256
Table 6-69: Global market for vVoIP VNF; by regional market 2017-2023 (\$ million)	256
Table 6-70: Global market for vProbe, vTA VNFs; by solution component 2017-2023 (\$ million)	257
Figure 6-34: Market share of vProbe, vTA VNFs, by solution component.....	257
Table 6-71: Global market for vProbe, vTA VNFs; by user segment 2017-2023 (\$ million).....	258
Table 6-72: Global market for vProbe, vTA VNFs; by regional market 2017-2023 (\$ million).....	258

1. EXECUTIVE SUMMARY

Insight Research conducted an in-depth market research forecast of SDN and NFV technologies. The exercise involved extensive primary research and exhaustive secondary research to build a comprehensive market forecast model.

This chapter highlights the salient findings of the market research report on Software-Defined Networks (SDN) and Network Functions Virtualization (NFV) technologies. The chapter also enumerates the prominent drivers for SDN and NFV technologies.

The Open Networking Forum (ONF) defines SDN as follows:

“Software-Defined Networking is an emerging architecture that is dynamic, manageable, cost-effective, and adaptable, making it ideal for the high-bandwidth, dynamic nature of today's applications. This architecture decouples the network control and forwarding functions enabling the network control to become directly programmable and the underlying infrastructure to be abstracted for applications and network services.”

NFV can be defined in the following manner:

“The migration from physical networking hardware to virtualized network functions is termed as Network Functions Virtualization.”

SDN and NFV mark the building of irreversible momentum towards software-enablement of telecommunications networks. While they sound similar, SDN and NFV are not interchangeable terms. SDN focuses on simplifying network design, deployment, management and troubleshooting functions; whereas NFV concerns itself with unshackling network equipment and devices from the clutches of proprietary technologies and migrate the network functions to general purpose hardware.

There are obvious elements of complementariness between SDN and NFV:

- NFV can facilitate scaling up of SDN setups
- SDN can simplify the instantiation, management and monitoring of NFV elements

1.1 SALIENT QUANTITATIVE OBSERVATIONS

The following table presents the global market for SDN and NFV.

Table 1-1: Global market for SDN and NFV 2017-2023 (\$ million)

	2017	2018	2019	2020	2021	2022	2023	CAGR
SDN	2,343	4,914	8,731	13,243	18,499	24,750	31,964	54.6%
NFV	4,824	5,688	6,735	8,017	9,585	11,464	13,699	19.0%
Total	7,167	10,602	15,466	21,260	28,084	36,214	45,663	36.2%

Source: Insight Research

Insight Research forecasts an attractive compounded annual growth rate (CAGR) more than thirty six percent for the combined SDN and NFV market. The market sizing for SDN involved independent assessment of key use-cases, while the market sizing for NFV technologies was derived from the market size for individual VNFs.

This report analyses the SDN technology market as a cumulative market of distinctive use-cases. Insight Research considers the following principal SDN use-cases:

- Central Office Rearchitected as Datacenter (CORD)
- Service Delivery/Fulfilment
- Network-as-a-Service (NaaS)/ Bandwidth on Demand (BoD)
- Mobile Network Virtualization/Network Slicing
- Software-Defined Wide Area Network (SD-WAN)
- Service Function Chaining

Similarly, the NFV market is organized as a cumulative market of multiple Virtual Network Functions (VNF). Insight Research considers fifteen major VNFs organized along six VNF categories.

The following figure summarizes the VNF categories and individual VNF types included in those categories

Figure 1-1: VNF categories and types

VNF Category	VNF Type
Switching and Routing	Virtual Load Balancer (vLB), Virtual Application Delivery Controller (vADC), Virtual WAN Optimizer (vWOC)
	vRouter, Virtual Carrier-Grade Network Address Translation (vCGNAT)
	vSwitch
Core WAN Functions	Virtual IP Multimedia Subsystem (vIMS), Virtual Call Session Control (vCSC), Virtual Policy and Charging Rules Function (vPCRF)
	Virtual Baseband Unit (vBBU), Virtual Radio Access Network (vRAN), extensible Radio Access Network (xRAN)
	Virtual Evolved Packet Core (vEPC), Virtual Voice over Long Term Evolution (vVoLTE)
Interfaces and Gateways	Virtual Advanced Media Software (vAMS), Virtual Session Border Controller (vSBC), Virtual Web Real-Time Communication (vWebRTC) Gateway (GW)
	Virtual Customer Premise Equipment (vCPE), Virtual Service Gateway (vSG)
	Virtual Wireless Access Gateway (vWAG)
Standard Device	Virtual Domain Name Server (vDNS)
	vFirewall
	Virtual Internet Protocol Security (IPSec), Virtual VPN (vVPN) Controller
IP Applications	Virtual Intelligent Messaging (vIM)
	Virtual Voice over Internet Protocol (vVoIP)
Testing	vProbe, Virtual Test Agent (vTA)

Source: Insight Research

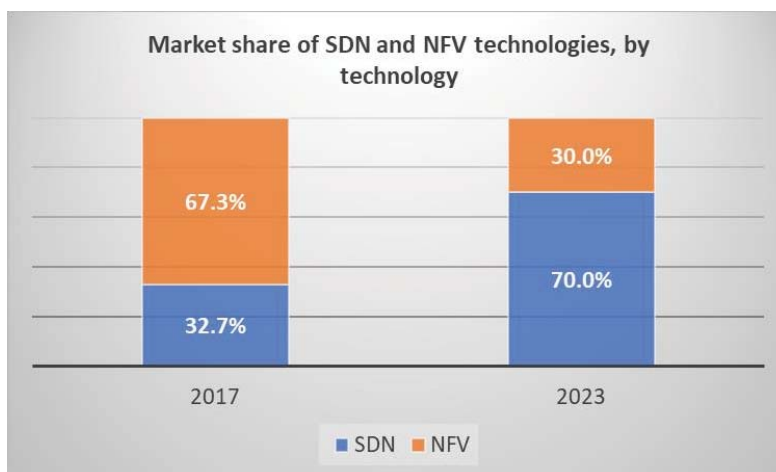
For a given VNF type, this report forecasts the cumulative market size of individual terms, excluding any overlapping references. While these are distinctive terms, they practically deliver the same function and can be used interchangeably.

There is a distinct dichotomy between the paths charted by each of these technologies individually.

Executive Summary

The following figure presents the market share of SDN and NFV technologies, by technology.

Figure 1-2: Market share of SDN and NFV technologies, by technology



Source: Insight Research

NFV is clearly the early leader. NFV owes its leadership to its varied user-base. It enjoys substantial traction from the Enterprise as well as from the Service Provider user segments. The Enterprise user-base will be instrumental in providing NFV with the early advantage. Enterprise-level implementation is performed at lower scales as compared to Service Provider-level integration. The implementation barrier is therefore substantially lower for Enterprises, whose decision-making is much faster than in case of Service Providers, wherein the higher stakes involved can slow down decision making.

SDN technologies will receive an overwhelmingly large chunk of their patronage from the Service Provider user-segment. SDN and NFV aim at eventually substituting conventional network elements and their networks. The market for such elements and networks is overwhelmingly skewed in favor of Service Providers. Service Providers will eventually dominate as they get increasingly attuned to benefits of these technologies. A turning point of sorts will be the fifth generation (5G) cellular network roll-outs.

SDN will therefore be a slow-starter, but the eventual market leader.

1.2 DRIVERS FOR SDN AND NFV

Any casual dipstick of contemporary discussion surrounding SDN and NFV will list a plethora of benefits that these technologies bring to the table. While there is some merit in the optimism exhibited by stakeholders, the outlook needs to be tempered with realism.

It is worthwhile taking a pragmatic look at the drivers that play a key role in the march towards SDN and NFV.

1.2.1 Service agility

Applications are being increasingly hosted on virtualized servers resulting in flexibility in resource management. The increasing use of mobile platforms and Bring Your Own Device (BYOD) in enterprises shows that end users are consuming application services belonging to different domains and presented in different forms, on the same device. Real time communications and high availability requires that applications and services be rolled out with high agility. This in turn means that networks need to support the agility demanded by these modern applications.

Telcos can leverage the capabilities provided by SDN and enable dynamic network services for their customers and help them migrate to modern IT applications infrastructure. Insight Research, during the course of the study, came across claims of reduction in implementation times to the extent of 70 percent.

As network control is decoupled from forwarding, more general-purpose hardware can be used to provide reliable and flexible network services. By adopting NFV, telcos can provision network services on-demand for their customers. Instead of a truck roll out for specialized network hardware, additional NFV instances can be created on the same generic CPE on the premises of the customer. If concerns related to resilience and availability are addressed satisfactorily, it is easy to visualize the time savings that telcos and their customers can accrue.

1.2.2 Centralized control

Server virtualization was clearly a software-based approach of solving the problem of running applications on dedicated hardware. In addition to the flexibility, the software control over application lifecycle provided administrators with powerful tools for managing, securing and troubleshooting applications.

In traditional IT organizations, it was common to have different teams to manage the server infrastructure and the network infrastructure. With the move towards an agile and dynamic IT application environment, this silo-based approach between compute and networks was a hindrance. Centralized control of the compute and network infrastructure that provides more integrated management can break these barriers.

Modern-day telco networks continue to grow in complexity. Telcos provide network services to a variety of customers from small businesses to large enterprises. The smaller

customers may use “managed services” that require the telcos to operate the network on behalf of the customer. And the large enterprises may want some operate some parts of their network on their own. From a telco perspective, these diverse requirements are best addressed using centralized control. Access control techniques can then be applied to provide different ways to operate the network.

The premise for centralization is not foolproof. Companies like Pluribus believe thoughtless centralization of the control plane can induce complexity in networks. Pluribus is convinced that it is heralding the new wave of SDNs by decentralizing the control plane.

1.2.3 Enhanced reliability

SDNs have borrowed heavily from server virtualization constructs to improve their reliability. This may sound counterintuitive. Server virtualization allowed applications to be shrink-wrapped and be hosted on any hardware server. If the underlying hardware had a fault, the entire application can be smoothly migrated to another hardware without the application realizing it. This reliability improvement provided by server virtualization required a corresponding support from the underlying network as well.

Taking cue from the portability provided by server virtualization, SDNs can also insulate the larger networks from localized faults. As telcos deploy and operate large telecom networks, the reliability of the network is of utmost importance. Using the abstraction provided by SDN, telcos can expand and enhance their network services independent of the network hardware. This independence also provides resilience against failures as both software and the hardware can be upgraded or changed independent of one another.

1.2.4 Software-driven approach

The traditional IT environment consisted mainly of physical networking hardware. It was common to have networking equipment from multiple vendors for various reasons. However, hardware from different vendors posed a challenge for interoperability and added complexity to the network design. Devices from different vendors may not support the same capabilities. This mismatch can be solved by applying software updates, but newer versions of networking software require initial soaking period, thereby slowing down the ability to roll out fresh networking capabilities. Applications that are tightly coupled with physical networks may also be impacted due to upgrade related outages.

In environments like datacenter and public clouds, the network needs to scale very rapidly with the demand for more computing and storage resources for applications. Designing a growing network with only physical devices is no longer a viable solution. Along with server and storage virtualization, the need for network virtualization is paramount.

Virtualization can be achieved by a software-driven approach so that applications are truly decoupled from the underlying network hardware. The reduced dependency with network hardware also minimizes the challenges associated with multi-vendor networks. A more software-based approach would provide network administrators with better tools and simplify the management by hiding the vendor-specific complexity. For example, with a software-based approach, applications can be moved within the data center such that parts of the network can be upgraded without impacting the applications. Software-driven approach also facilitates dynamic alteration in security parameters.

1.2.5 Cost savings

Instead of using specialized network hardware, businesses can now use general purpose compute to host VNFs. General-purpose hardware straightaway reduces the capital expenditure and eliminates the dependency on network hardware vendor. The VNFs can be provisioned on demand and can even be scaled up or down based on the load on the network. Telcos can therefore offer more software subscription-based services and thereby lower the operating expenses for their customers. The pay-as-you-go approach of consuming enterprise applications can now be adopted for network services as well.

The benefits of cost savings are not restricted to NFV implementations. SDN fundamentally postulates a determined move towards generalized COTS hardware. Individual vendors will offer products with SDN functionality. In ideal scenarios, the differences between products offered by varied vendors will continue to diminish. SDN will be the torchbearer towards standardization in the long run.

1.2.6 Vendor neutral hardware

The approach of using physical networking hardware has several challenges. Vendor lock-in is the gravest of these challenges. Multi-vendor installations can lead to interoperability challenges. By using x86 based servers to run VNFs it is possible to be immune from vendor-specific hardware challenges. Telcos can also offer the x86 based platforms as Customer Premises Equipment (CPE) devices and allow them to run multi-vendor VNF on them.

The move towards vendor neutral hardware has grave implications for established players such as Broadcom, who dominate the switch fabric market. The limitations of this approach should also be understood. General-purpose hardware can never substitute Application-Specific Integrated Circuits (ASIC) in core switching functions for the foreseeable future.

1.2.7 Optimal utilization of resources

Optimal resource utilization is the most significant driver for the adoption of NFV. The virtual network functions are quite simply software entities that can be created and destroyed on demand. Users need not wait for new hardware to arrive and be physically connected for use. For example, if a network is being subjected to a Distributed Denial-of-Service (DDoS) attack, NFV can facilitate seamless deployment of more firewall and IPS instances to thwart the attack. Once the threat is neutralized, the instances can be destroyed, ensuring that the x86 hardware resources are used optimally.

1.2.8 Flexibility in network design

With only basic network connectivity implemented using physical cables, the logical network becomes more significant. Network virtualization supports seamless isolation independent of underlying physical connectivity. By applying SDN methodologies it is possible to create more flexible and adaptive network design to support complex application requirements.

1.2.9 Benign effect on capital and operating expenditure

x86 based servers require much lesser capital investment. There is considerable protection against hardware faults when compared to dedicated networking hardware. NFV instances are treated like software entities and can be deployed using subscription-based licensing. This is beneficial from an operating expense perspective.

The optimism towards cost savings needs to be tempered in the short run. Service Providers and Enterprises will need to equip themselves to manage operations in a software-driven environment. The reskilling of resources will lead to a short-term dent in the cost savings accrued from SDN and NFV technologies.

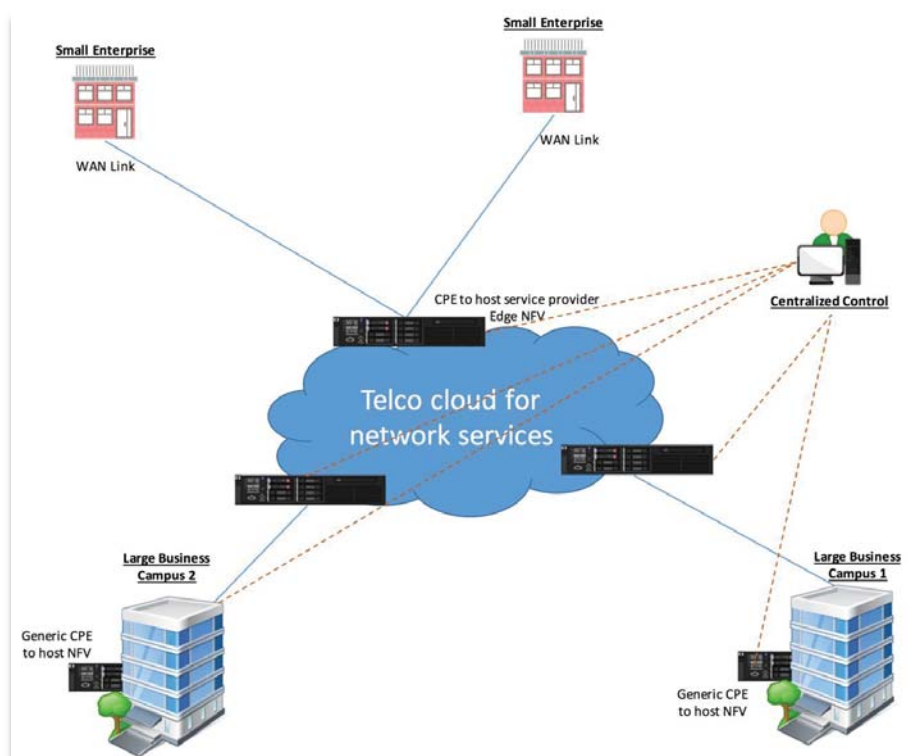
1.2.10 Ownership of feature-rich services

NFV based approach allows telecom service providers to offer a broad range of networking services and features as VNFs. Centralized control allows end users to provision and consume the services that they desire. Therefore, consumers can mix and match VNFs from different network vendors and design a network service chain suits their need. The ability to choose the network service along with the full control to operate it can be provided to end users using this architecture.

1.2.11 Takeaways for telcos from SDN and NFV

The following figure shows how telco network services can be provided to small enterprises and large businesses using SDN and NFV technologies.

Figure 1-3: Telco cloud and networking services.



Source: Insight Research

Small enterprises can leverage the *virtualized* network functions such as Firewall, Intrusion Prevention that are hosted *inside* the telco cloud. This eliminates the need for an on-premise complex network CPE thereby reducing capex for the small enterprises without compromising on the functionality. The Software-as-a-Service (SaaS) model of pay-as-you-go can be applied to these network services hosted in the telco cloud.

Large businesses require more sophisticated network capabilities on their premises. The same general-purpose hardware, that hosts VNFs for the telcos, can be reused as a simple CPE that can host VNFs such as Firewall, WAN Optimizers inside the branches of large businesses. These VNFs use WAN links to connect to their peer network services running inside telco cloud.

Executive Summary

The above is a very simplistic explanation. Its very simplicity has prompted telcos such as AT&T to launch FlexWare, it's virtual CPE offering on an aggressive scale, as its debut into the VNF space.

In essence, SDN and VNF technologies enable telcos to adopt a graded approach towards customer engagement. Telcos can debut with less complex VNFs like vCPE and then move towards more intricate SDN and NFV constructs.