The ACADEMY

DISCOVER LEARN CERTIFY

SDWAN
BOOT CAMP
SURVIVAL GUIDE

Welcome to Boot Camp

This survival guide will help you prepare for one of the most informative and intensive training missions that you will ever embark on. We have included some of our most effective training tools and a mission plan to help you get ready to become a Certified SDWAN Expert.

What's included:

- The exam blueprint with all the topics covered on the exam to help you understand the core SDN/NFV, Automated Network Orchestration and SDWAN concepts that you'll need to master in order to graduate Boot Camp and go on to become a Certified Professional
- Key training tools that explain the basics of SDWAN services attributes and components
- A quiz to give you an example of what will be expected of you when you're ready to take the MEF-SDWAN examination.
- An acronym guide to help you learn the language of SDN/NFV and SDWAN.

But if you're not quite ready to go it alone, we've included an overview of our award winning Drill Instructor-led training program that more than 5000 fellow professionals have used to earn their certifications.

All of us at the SDWAN Academy, wish you all the best in your exam preparation, and if you're looking for a "boost over the wall", do not hesitate to contact us and ask for a push! We're standing by eager and ready to help you earn your stripes!

Craig Easley – Master Drill Instructor and Dean of Academic Affairs

Basic SDWAN Concepts

❑ Software Defined Networking components
❑ Separation of the management, control and data forwarding planes
  o Enables logically centralized view of network-wide routing and switching paths
❑ Programmatically configured
  o Routing and Switching applications determine flow paths
  o SDN Controller receives direction from the application via the Northbound RESTful APIs with the applications
  o SDN Controller then programmatically configures SDN switches via OpenFlow protocol
  o SDN Switches contain flow tables populated with flow patterns and action when a match between a flow pattern and a table rule occurs
❑ SDN Controller executes the routing and switching logic
❑ SDN switches are simple pattern match and action execution engines
❑ Openflow is the protocol connecting the Controller and OpenFlow Virtual Switch (OvSwitch)
❑ Secure communication channels enable trusted operation and Redundant Controllers
  o East-West interfaces enables controllers to synchronize with each other

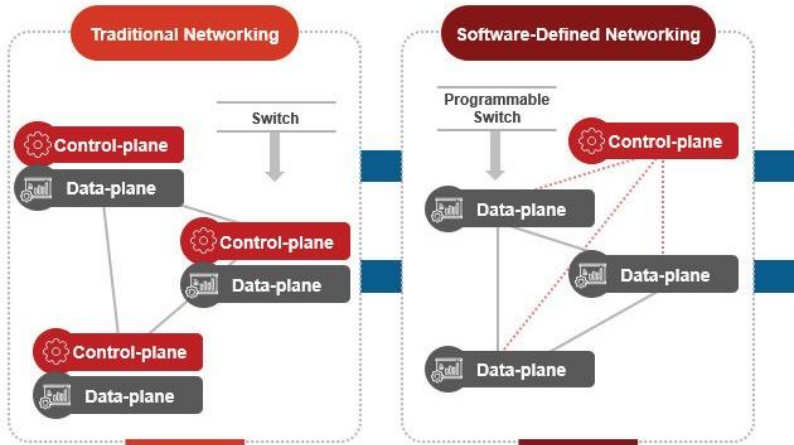# SDN/NFV Framework
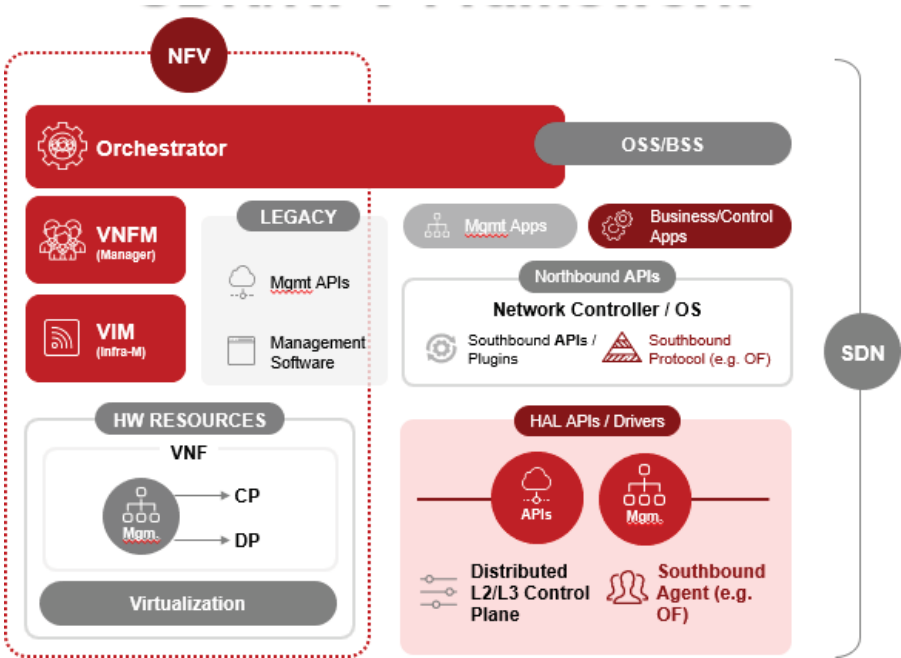
Separation of Control and Data Planes

- ❏ Management Plane
  - ❏ Provision, configure, monitor and measure
- ❏ Control Plane
  - ❏ Switching and routing
  - ❏ Route selection and rules application
- ❏ Data Plane
  - ❏ Buffer, filter, forward, mark
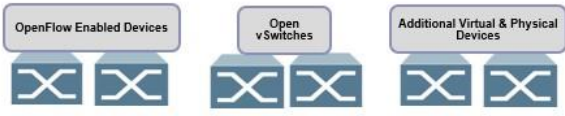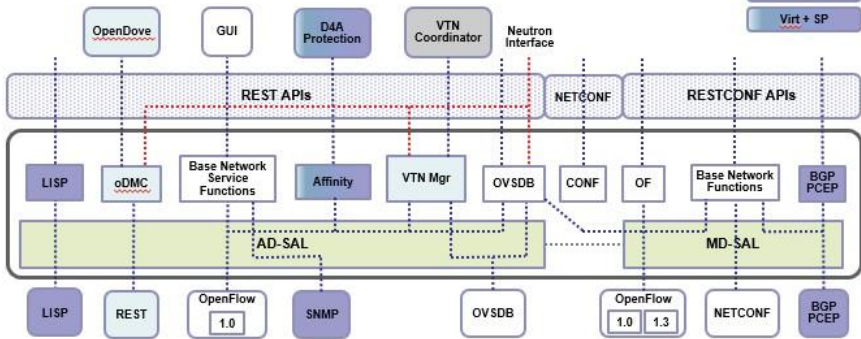 - ❏ Transmission and reception
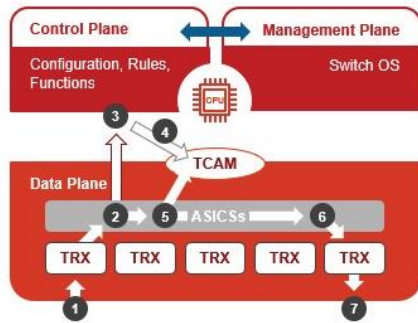
Logically Centralized Control

OpenDayLight SDN Controller

❑ Myriad of software based controllers were developed to provide switching/routing and control processing for OvSwitches
- o NoX – Nicira OpenFlow Controller
- o PoX – Pythonic OpenFlow Controller
- o Floodlight
- o OpenDayLight

❑ OpenDayLight has been the most widely adopted

❑ ODL includes a variety of Layer 2 (Modular Layer 2 ML2) and Layer 3 routing

❑ Model-driven Service Abstraction Layer (MD-SAL)
- o Support a variety of controller to switch protocols
- o OpenFlow for native OvSwitches
- o NetConf / YANG device configuration for legacy switches
- o Routing protocol switch updates including BGP-LS and PCEP

❑ Base, Service Provider and Virtualized ODL Editions
- o Meets a variety of SDN deployment requirements

❑ OpenDayLight evolved to include a number of Orchestrator-like automation features

❑ The Mininet SDN Simulator enables building a fully functional SDN network with a controller, switches and hosts in a variety of network topologies and configurations including with external ODL (and other) controllers
- o **www.mininet.org**

OPEN DAYLIGHT

Base Network Service Functions

Topology Mgr | Stats Mgr | Switch Mgr | Fwding Ruls Mgr | Host Tracker | ARP Handler

Base
Virtualization
Service Provider
Virt + SP

OpenDove | GUI | D4A Protection | VTN Coordinator | Neutron Interface

REST APIs | NETCONF | RESTCONF APIs

LISP | oDMC | Base Network Service Functions | Affinity | VTN Mgr | OVSDB | CONF | OF | Base Network Functions | BGP PCEP

AD-SAL | MD-SAL

LISP | REST | OpenFlow 1.0 | SNMP | OVSDB | OpenFlow 1.0 1.3 | NETCONF | BGP PCEP

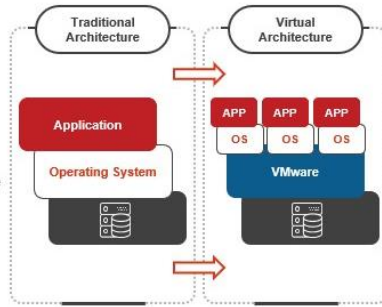OpenFlow Enabled Devices | Open vSwitches | Additional Virtual & Physical Devices

OF: OpenFlow
D4A: Defense for All
VTN: Virtual Tenant Network
oDMC: Open Dove Management console
LISP: Locator/Identifier Separation Protocol
OVSDB: Open vSwitch DataBase protocol
BGP: Border Gateway Protocol
PCEP: Path Computation Element Protocol
SNMP: Simple Network Management Protocol
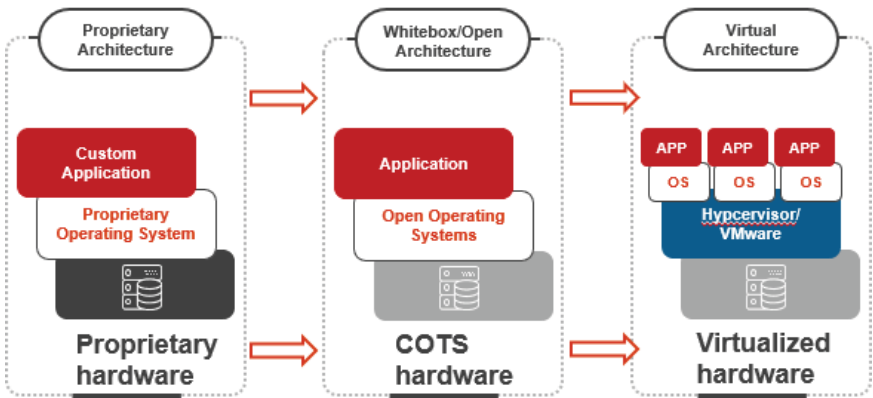
Virtualization Concepts

- ❑ Type 1 virtualization hypervisors – "Bare-metal" replacing the machines operating system
- ❑ Type 2 virtualization hypervisor – "Hosted" running on the machines local operating system
- ❑ Virtual Machines (vm) are created at runtime, by defining a "name space" which creates boundaries around the compute, storage and network resources that the vm can access
- ❑ Inter-vm communication is done by sending messages to a virtual NIC or bridge which connects the vm's to one another
- ❑ An important factor to consider when virtualizing certain application is the latency that is introduced by this inter-vm communication. The Data Plane Development Kit (DPDK) was designed to address some of the performance impacting overhead latencies.
- ❑ While virtualization has been widely implemented by IT applications (web servers, storage, etc.) and in data centers, it is only beginning large scale deployment in telecommunications networks
- ❑ The ETSI Network Function VIrtualisation (NFV) Industry Standards Group (ISG) is defining a comprehensive architecture and framework of virtualization standards, and reference points (APIs) between NFV functional components
- ❑ The ETSI NFV/MANO architecture includes 3 main function blocks
- ❑ NFV Orchestrator
- ❑ NVF Manager
- ❑ Virtual Infrastructure Manager (VIM

Follow the Trend to Virtualization

- ❑ Break the monolithic application=appliance approach
- ❑ Computer virtualization allows multiple apps to share the same hardware
- ❑ Concept is similar in networking
- ❑ Virtualize functions and implement "instances" rather than new appliances

Steps Towards Virtualization

Proprietary Architecture	Whitebox/Open Architecture	Virtual Architecture
Custom Application	Application	APP APP APP
Proprietary Operating System	Open Operating Systems	OS OS OS / Hypcervisor/VMware
Proprietary hardware	COTS hardware	Virtualized hardware

The ETSI NFV Framework
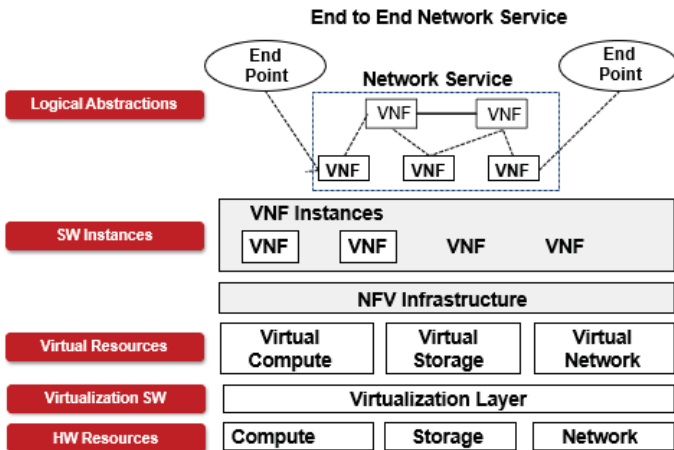
NFV MANO Reference Architecture

End-to-End-Service Chaining Function Graphs

SDWAN Components and Attributes

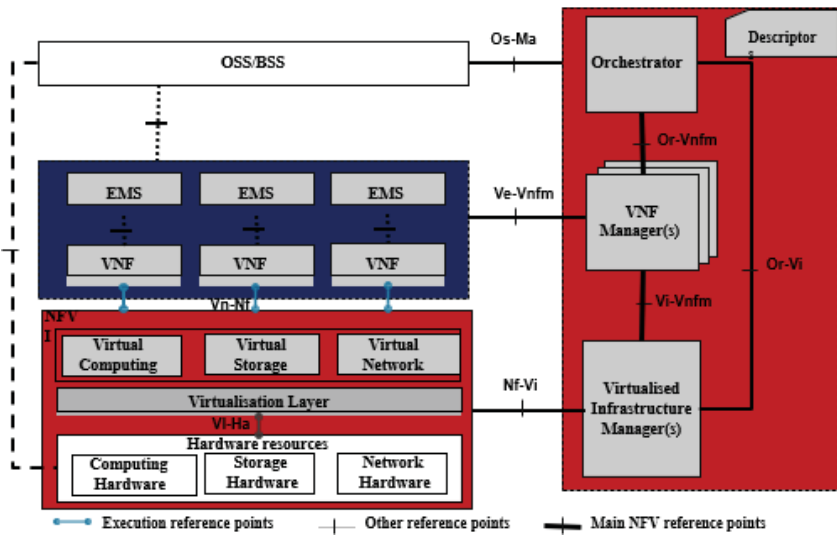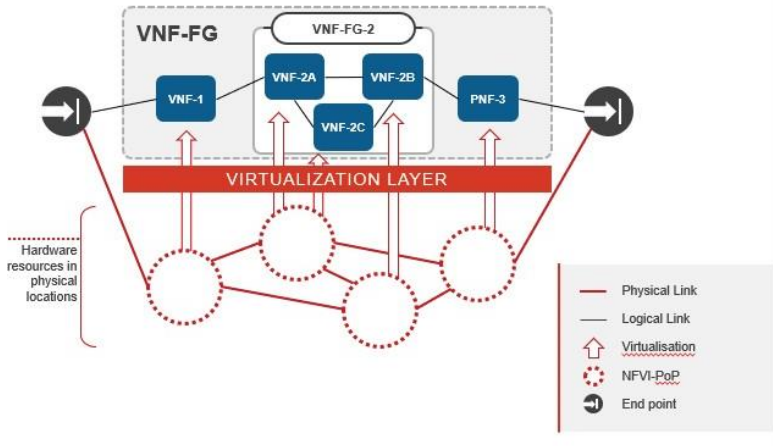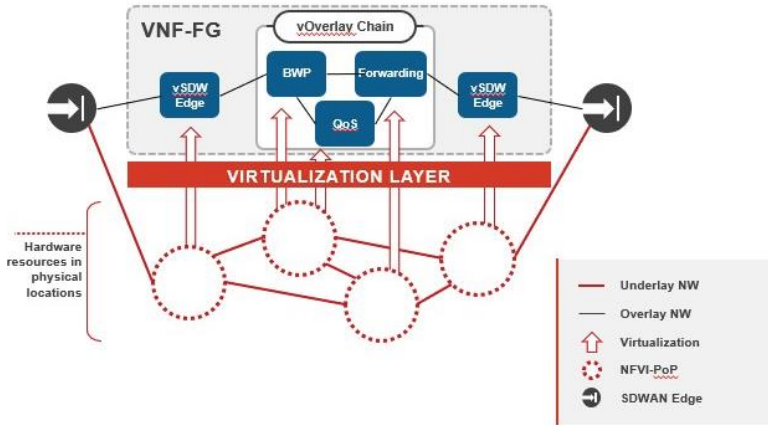- ❑ MEF and ONUG have been jointly working to create the industry's first SDWAN Standard
- ❑ MEF 70 represents the first milestone towards and SDWAN Service standard
- ❑ MEF 70 is a catalog of services attributes similar to MEF 10 for Carrier Ethernet services and MEF 61 IP Services Attributes and MEF 63 Subscriber level optical transport services (Yes they got the numbers ass-backwards 61 - Layer3 and 63 - Layer1 😉)
- ❑ MEF 70 defines the following Key Concepts and Definitions
    - o SDWAN Service Attributes
    - o SDWAN Service Components
    - o Underlay Connectivity Services (UCS)
    - o Tunnel Virtual Connection (TVC)
    - o SDWAN Virtual Connections and SWVC End Points
- ❑ MEF 70 defines a comprehensive set of Service Attributes
    - o SDWAN Virtual Connections (SWVC) Attributes
    - o SDWAN Virtual Connections (SWVC) End Point Attributes
    - o SDWAN UNI Attribute
- ❑ MEF 70 further describes Application Flow Policy application, common SDWAN Use Cases
- ❑ MEF 90 is a draft MEF Certification test for SDWAN Service

NFV SDWAN Service Chain

SDWAN Overview

SDWAN Edge
Physical or virtual

SDWAN Gateway
Between SDWAN and external connectivity services

SDWAN Controller
Centralized management of SDWAN edges & gateways

Service Orchestrator
Lifecycle Service Orchestration of SDWAN and other services

Subscriber Web Portal
Subscriber service ordering and modification

https://www.mef.net/mef-3-0-SDWAN

Acronym Guide

Term/Abbreviation/ Acronym	Definition
3GPP	Third generation partnership project
Abstraction	A representation of an entity in terms of selected characteristics, while hiding or summarizing characteristics irrelevant to the selection criteria.
Access Provider	A wide area network service provider that delivers connectivity between an ENNI and one of more UNIs
ACL	Access Control List
A-CPI	Application-controller plane interface
AES	Advanced Encryption Standard
Agile	Relating to a Service Provider's ability to rapidly introduce new, on demand services using new technologies without disrupting their top-to-bottom operational environment. Agility can be achieved via proper product / service / resource abstractions using APIs and orchestration.
API	Application Program Interface. In the context of LSO, API describes one of the Management Interface Reference Points based on the requirements specified in an Interface Profile, along with a data model, the protocol that defines operations on the data and the encoding format used to encode data according to the data model.
ARP	Address Resolution Protocol
ASIC	Application-Specific Integrated Circuit

Term/Abbreviation/ Acronym	Definition
Assured	Relating to the Customer's expectations that a network Connectivity Service will provide consistent performance and security assurances to meet the needs of their applications.
BGP	Border Gateway Protocol
Broadcast	Broadcast or flooding is a simple routing algorithm in which every incoming packet is sent through every outgoing link except the one it arrived on.
BSS	Business Support System
Business Process Flow	Graphically represents the behavior of Process Elements in an "end-to-end" or "through" Process view across the business (i.e., Enterprise).
CAPEX	CAPital EXpenditure. Money spent by a business or organization on acquiring or maintaining fixed assets, such as land, buildings, and equipment.
CE 2.0	Carrier Ethernet 2.0 generation
CHAP	Challenge Handshake Redundancy Protocol
CLI	Command Line Interface
CO	Central Office. A CO contains at least one Class-5 telephone switch, which is a telephone switch or telephone exchange in the public switched telephone network located at the local telephone company's central office, directly serving subscribers. Class-5 switch services include basic dial-tone, calling features, and additional digital and data services to subscribers connected to a local loop.

Term/Abbreviation/ Acronym	Definition
Compute Domain	Domain within the NFVI that includes servers and storage
Compute Note	Abstract definition of a server
Controller	see *SDN Controller*
Connectivity Service	A service delivering network connectivity (i.e. traffic) among service access points described by a set of both static and/or dynamic service attributes.
CPU	Central Processing Unit; device in the compute node that provides the primary container interface
Customer	A Customer is the organization purchasing, managing, and/or using Connectivity Services from a Service Provider. This may be an end user business organization, mobile operator, or a partner network operator.
DC	Data Center
Data link layer	The second lowest layer of the seven-layer Open Systems Interconnection (OSI) model of computer networking.
Data Model	Models managed objects based on an Information Model at a more detailed level using a specific data modeling language. Data modeling languages include XSD, IDL, and YANG.
DDoS	Distributed Denial of Service. In computing, a denial-of-service attack (DDoS attack) is a cyber-attack where the perpetrator seeks to make a machine or network resource unavailable to its intended users by temporarily or indefinitely disrupting services of a host connected to the Internet. Denial of service is typically accomplished by flooding the targeted machine or resource with superfluous requests in an attempt to overload systems and prevent some or all legitimate requests from being fulfilled.

Term/Abbreviation/ Acronym	Definition
DHCP	Dynamic Host Configuration Protocol
DPI	Deep Packet Inspection
DNS	Domain Name System
EMS	Element Management System. A management system used to manage the individual network elements as well as the networks that connect them. One or more EMSs may be deployed within a Service Provider management domain depending on the different supplier products and geographic distribution of the network elements in the network.
ENNI	External Network-to-Network Interface. A reference point representing the boundary between two Operator networks that are operated as separate administrative domains.
EPL	Ethernet Private Line
EVC	Ethernet Virtual Connection. An association of two or more Ethernet UNIs.
East-West SDN Architecture	How entities within the same plane of the SDN architectures interrelate
FEC	Forward Error Correction
Flood	Flooding is a simple routing algorithm in which every incoming packet is sent through every outgoing link except the one it arrived on.
Frame	A unit of data transferred over a L2 network

Term/Abbreviation/ Acronym	Definition
FTP	File Transfer Protocol
FOSS	Free and Open Source Software
Forwarding Construct (FC)	Enabled forwarding between two or more LTPs which supports any transport protocol including all circuit and packet forms.
Forwarding Domain (FD)	The topological component which represents the opportunity to enable forwarding between points represented by LTPs.
Functional Management Entity	A set of specific management layer functionality within the LSO Reference Architecture.
HTTP	Hypertext Transfer Protocol. A stateless application-level protocol for distributed, collaborative, hypertext information systems.
HTTPS	Hypertext Transfer Protocol Secure
IaaS	Infrastructure as a Service. (IaaS) refers to online services that provide high-level APIs used to de-reference various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, backup etc. A hypervisor runs the virtual machines as guests. Pools of hypervisors within the cloud operational system can support large numbers of virtual machines and the ability to scale services up and down according to customers' varying requirements. IaaS clouds often offer additional resources such as a virtual-machine disk-image library, raw block storage, file or object storage, firewalls, load balancers, IP addresses, virtual local area networks (VLANs), and software bundles
iBGP	Interior Border Gateway Protocol
ICMP	Internet Control Message Protocol

Term/Abbreviation/ Acronym	Definition
IDS	Intrusion Detection System
Information model	A set of entities, together with their attributes and the operations that can be performed on the entities. An instance of an information model is visible at an interface. Models managed objects at a conceptual level, independent of any specific implementations or protocols used to transport the data. Information models may be described using UML class diagrams.
INNI	Internal Network-to-Network Interface. A reference point representing the boundary between two networks or network elements that are operated within the same administrative domain.
Interface Profile	Defines the structure, behavior, and semantics supporting a specific Management Interface Reference Point identified in the LSO Reference Architecture. The Interface Profile specification contains all the necessary information to implement the related API, including objects, attributes, operations, notifications, and parameters.
iSCSI	Internet Small Computer Systems Interface
IPS	Intrusion Prevention System
IP	Internet Protocol
IP address	The unique value assigned to each host on a computer network that is employing the Internet Protocol for addressing
IPsec	Internet Protocol Security
IPv4	Internet Protocol Version 4, using a 32-bit integer value for host addressing

Term/Abbreviation/ Acronym	Definition
IPv6	Internet Protocol Version 6, using a 128-bit integer value for host addressing
IS-IS	Intermediate System to Intermediate System protocol
JavaScript Object Notation (JSON)	A text format that facilitates structured data interchange between all programming languages.
Layer	A stratum in a framework that is used to describe recursion within the data plane. Adjacent layers have a client-server relationship.
Layer 1 or Layer One or L1	See Physical layer in the OSI model
Layer 2 or Layer Two or L2	See data link layer in the OSI model
Layer 3 or Layer Three or L3	See the network layer in the OSI model
Layer 4 or Layer Four or L4	See the transport layer in the OSI model
Layer 5 or Layer Five or L5	See the session layer in the OSI model
Layer 6 or Layer Six or L6	See the presentation layer in the OSI model
Layer 7 or Layer Seven or L7	See the application layer in the OSI model
Level	A stratum of hierarchical SDN or networking abstraction.

Term/Abbreviation/ Acronym	Definition
LAN	Local Area Network
LIFO	Last In/First Out
LLDP	Link Layer Discovery Protocol
Lifecycle Service Orchestration (LSO)	Open and interoperable automation of management operations over the entire lifecycle of Layer 2 and Layer 3 Connectivity Services. This includes fulfillment, control, performance, assurance, usage, security, analytics and policy capabilities, over all the network domains that require coordinated management and control in order to deliver the service. LSO is an agile approach to streamlining and automating the service lifecycle in a sustainable fashion for coordinated management and control across all network domains responsible for delivering an end-to-end Connectivity Service (e.g., Carrier Ethernet, IP VPN, MPLS, etc.).
LSO Reference Architecture	A layered abstraction architecture that characterizes the management and control domains and entities, and the interfaces among them, to enable cooperative orchestration of Connectivity Services.
Logical Termination Point (LTP)	Termination point that encapsulates the termination, adaptation and OAM functions of one or more transport layers.
MAC	Media Access Control
MAN	Metropolitan Area Network
MANO	Management and Orchestration (see also NFV MANO)
Management Abstraction	A management view of information categories and high-level information classes that hides the details of the underlying complexity. LSO identifies Management Abstractions for the Product, Service, and Resource views.
Management Interface Reference Point	The logical point of interaction between specific management entities

Term/Abbreviation/ Acronym	Definition
MPLS	Multiprotocol Label Switching Protocol
NaaS	Network-as-a-Service
NAT	Network Address Translation
Network Control Domain	Manages the subnetwork boundary edge to subnetwork boundary edge aspects of the network connectivity along with the resources and infrastructure under its control within a specific subnetwork domain.
Network controller	Functional block that centralizes some or all of the control and management functionality of a network domain and may provide an abstract view of its domain to other functional blocks via well-defined interfaces (ETSI)
Network forwarding path	Ordered list of connection points forming a chain of NFs, along with policies associated to the list (ETSI)
Network Function (NF)	Functional block within a network infrastructure that has well-defined external interfaces and well-defined functional behavior. In practical terms, a Network Function is today often a network node or physical appliance. (ETSI)
NF set	A collection of NFs with unspecified connectivity between them (ETSI)
Network forwarding graph	The graph of logical links connecting NF nodes for the purpose of describing traffic flow between these network functions (ETSI)
Network layer	Provides the functions and processes that allow data to be transmitted from sender to receiver across multiple intermedia networks.
Network operator	Defined as an operator of an electronics communications network or part thereof. An association or organization of such network operators also falls within this category (ETSI)

Term/Abbreviation/ Acronym	Definition
NFV	Network Functions Virtualization. The principle of separating network functions from the hardware they run on by using virtual hardware abstraction (ETSI). Network functions virtualization (NFV) is an initiative to virtualize the network services that are now being carried out by proprietary, dedicated hardware. If successful, NFV will decrease the amount of proprietary hardware that's needed to launch and operate network services.
NFVI	Network Functions Virtualisation Infrastructure (NFVI): totality of all hardware and software components that build up the environment in which VNFs are deployed. The NFV-Infrastructure can span across several locations, e.g. places where data centers are operated. The network providing connectivity between these locations is regarded to be part of the NFV- Infrastructure. NFV-Infrastructure and VNF are the top-level conceptual entities in the scope of Network Function Virtualization. All other components are sub-entities of these two main entities. (ETSI)
NFVI Components	Network Functions Virtualisation Infrastructure (NFVI) components: NFVI hardware resources that are not field replaceable, but are distinguishable as COTS components at manufacturing time (ETSI)
NFV component	NFVI hardware resource that is not field replaceable, but is distinguishable as a COTS component at manufacturing time (ETSI)
NFV framework	The totality of all entities, reference points, information models and other constructs defined by the specifications published by the ETSI ISG NFV
NFVI Node	Network Functions Virtualisation Infrastructure Node (NFVI-Node): physical device[s] deployed and managed as a single entity, providing the NFVI Functions required to support the execution environment for VNFs (ETSI)
NFV Orchestrator (NFVO)	The functionality that coordinates the management of the connectivity lifecycle, Virtualized Network Functions (VNF) lifecycle, and Network Functions Virtualization Infrastructure (NFVI) resources to ensure an optimized allocation of the necessary supporting resources and connectivity. The functional block that manages the Network Service (NS) lifecycle and coordinates the management of NS lifecycle, VNF lifecycle (supported by the VNFM) and NFVI resources (supported by the VIM) to ensure an optimized allocation of the necessary resources and connectivity (ETSI)
NFVI-PoP	Network Function Virtualisation Infrastructure Point of Presence (NFVI-PoP): N- PoP where a Network Function is or could be deployed as Virtual Network Function (VNF) (ETSI)

Term/Abbreviation/ Acronym	Definition
NFV-MANO	Network Functions Virtualisation Management and Orchestration (NFV-MANO): functions collectively provided by NFVO, VNFM, and VIM (ETSI)
NFV-MANO Architectural Framework	Network Functions Virtualisation Management and Orchestration Architectural Framework (NFV-MANO Architectural Framework): collection of all functional blocks (including those in NFV-MANO category as well as others that interwork with NFV-MANO), data repositories used by these functional blocks, and reference points and interfaces through which these functional blocks exchange information for the purpose of managing and orchestrating NFV (ETSI)
Network Service	A template that describes the deployment of a Network Service including service
Descriptor	topology (constituent VNFs and the relationships between them, Virtual Links, VNF Forwarding Graphs) as well as Network Service characteristics such as SLAs and any other artefacts necessary for the Network Service on-boarding and lifecycle management of its instances (ETSI)
Network Service Orchestration	The subset of NFV Orchestrator functions that are responsible for Network Service lifecycle management (ETSI)
Network Stability	The ability of the NFV framework to maintain steadfastness while providing its function and resume its designated behavior as soon as possible under difficult conditions, which can be excessive load or other anomalies not exceeding the design limits.
Network Service Provider	A type of Service Provider implementing the Network Service
NIC	Network Interface Controller (NIC): device in a compute node that provides a physical interface with the infrastructure network (ETSI)
NOC	Network Operations Center

Term/Abbreviation/ Acronym	Definition
NBI	North Bound Interface (see SDN Architecture). In a software-defined network (SDN) architecture, the northbound application program interfaces (APIs) are used to communicate between the SDN Controller and the services and applications running over the network. The northbound APIs can be used to facilitate innovation and enable efficient orchestration and automation of the network to align with the needs of different applications via SDN network programmability.
NFaaS	Network Functions-as-a-Service
NOS	Network Operating System
NV-GRE	Network Virtualization Using Generic Routing Encapsulation
OAM	Operations, Administration, and Maintenance
Object Class	Used to convey the representation of an entity, including behavior, properties, and attributes. An instance of an Object Class may be referred to as an Object.
OC	Optical Carrier
OFA	OpenFlow agent
OFC	OpenFlow controller
OPEX	OPerational EXpense. An operating expense, operating expenditure, operational expense, operational expenditure or OPEX is an ongoing cost for running a product, business, or system. Its counterpart, a capital expenditure (CAPEX), is the cost of developing or providing non-consumable parts for the product or system. For example, the purchase of a photocopier involves CAPEX, and the annual paper, toner, power and maintenance costs represents OPEX. For larger systems like businesses, OPEX may also include the cost of workers and facility expenses such as rent and utilities.

Term/Abbreviation/ Acronym	Definition
Operator Service Endpoint	The demarcation points between network operators
OSS	Operational Support System
Operator Virtual Connection (OVC)	An association of "external interfaces" within the same Operator network.
Orchestrated	Relating to automated service management across potentially multiple operator networks which includes fulfillment, control, performance, assurance, usage, security, analytics, and policy capabilities, which are achieved programmatically through APIs that provide abstraction from the particular network technology used to deliver the service.
OS	Operating System
OSPF	Open Shortest Path First
OTN	Optical Transport Network
OTT	Over the Top
OTU	Optical Channel Transport Unit
Overlay Architecture	An overlay network is a computer network that is built on top of another network
OVSDB	Open vSwitch database management protocol
Packet	a unit of data transferred over an L3 network.
Packet Switch	A packet switch is a node in a network, which uses the packet switching paradigm for data communication. Packet switches can operate at a number of different levels in a protocol suite; although the exact technical details differ, fundamentally they all perform the same function: they store and forward packets.

Term/Abbreviation/ Acronym	Definition
Partner	An organization providing Products and Services to the Service Provider in order to allow the Service Provider to instantiate and manage Service Components external to the Service Provider domain.
Physical layer	lowest layer of the seven-layer Open Systems Interconnection (OSI) model of computer networking
Physical Network Function (PNF)	The implementation of a NF via a tightly coupled software and hardware system (ETSI)
Pipeline Processing	A chain of data-processing processes or other software entities
PaaS	Platform-as-a-Service
PNF	Physical Network Function
Public Key Infrastructure (PKI)	A public key infrastructure (PKI) is a set of roles, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates and manage public-key encryption. The purpose of a PKI is to facilitate the secure electronic transfer of information for a range of network activities such as e- commerce, internet banking and confidential email. It is required for activities where simple passwords are an inadequate authentication method and more rigorous proof is required to confirm the identity of the parties involved in the communication and to validate the information being transferred. In cryptography, a PKI is an arrangement that binds public keys with respective identities of entities (like people and organizations). The binding is established through a process of registration and issuance of certificates at and by a certificate authority (CA). Depending on the assurance level of the binding, this may be carried out by an automated process or under human supervision.
Port	A virtual data connection between computer programs connected through a computer network

Term/Abbreviation/ Acronym	Definition
Process	A systematic, sequenced set of functional activities that deliver a specified result. In other words, a Process is a sequence of related activities or tasks required to deliver results or outputs.
Product Lifecycle	The sequence of phases in the life of a Product Offering, including definition, planning, design and implementation of new Product Offerings, changes for existing Product Offerings, and the withdrawal and retirement of Product Offerings.
P-SDN	Packet-Software Defined Networking
PSTN	Public Switched Telephone Network
QOS	Quality of Service
RDP	Remote Desktop Protocol
Resilience	In an NFV network, the ability of the NFV framework to limit disruption and return to normal or at a minimum acceptable service delivery level in the face of a fault, failure, or an event that disrupts the normal operation (ETSI)
Resource	A physical or non-physical component (or some combination of these) within a Service Provider's infrastructure or inventory.
Return on Investment (ROI)	Return on Investment (ROI) is the benefit to an investor resulting from an investment of some resource. A high ROI means the investment's gains compare favorably to its cost. As a performance measure, ROI is used to evaluate the efficiency of an investment or to compare the efficiencies of several different investments. In purely economic terms, it is one way of relating profits to capital invested.

Term/Abbreviation/ Acronym	Definition
Router	A router is a networking device that forwards data packets between computer networks. A router is connected to two or more data lines from different networks (as opposed to a network switch, which connects data lines from one single network). When a data packet comes in on one of the lines, the router reads the address information in the packet to determine its ultimate destination. Then, using information in its routing table or routing policy, it directs the packet to the next network on its journey.
RSVP	Resource Reservation Protocol
SaaS	Software-as-a-Service
Scaling	The ability to dynamically extend/reduce resources granted to the Virtual Network Function (VNF) as needed. NOTE: This includes scaling up/down and scaling out/in. Scaling out/in: ability to scale by add/remove resource instances (e.g. VM) (ETSI)
SDN	Software Defined Networking. (SDN) technology is an approach to computer networking that allows network administrators to programmatically initialize, control, change, and manage network behavior dynamically via open interfaces and provide abstraction of lower-level functionality. SDN is meant to address the fact that the static architecture of traditional networks doesn't support the dynamic, scalable computing and storage needs of more modern computing environments such as data centers. This is done by decoupling or disassociating the system that makes decisions about where traffic is sent (the SDN controller, or control plane) from the underlying systems that forward traffic to the selected destination (the data plane). SDN was commonly associated with the OpenFlow protocol (for remote communication with network plane elements for the purpose of determining the path of network packets across network switches) since the latter's emergence in 2011. Since 2012, however, many companies have moved away from OpenFlow, and have embraced different techniques. These include Cisco Systems' Open Network Environment and Nicira's network virtualization platform.

Term/Abbreviation/ Acronym	Definition
SDN Architecture	The SDN architecture is: • Directly programmable: Network control is directly programmable because it is decoupled from forwarding functions. • Agile: Abstracting control from forwarding lets administrators dynamically adjust network-wide traffic flow to meet changing needs. • Centrally managed: Network intelligence is (logically) centralized in software-based SDN controllers that maintain a global view of the network, which appears to applications and policy engines as a single, logical switch. • Programmatically configured: SDN lets network managers configure, manage, secure, and optimize network resources very quickly via dynamic, automated SDN programs, which they can write themselves because the programs do not depend on proprietary software. • Open standards-based and vendor-neutral: When implemented through open standards, SDN simplifies network design and operation because instructions are provided by SDN controllers instead of multiple, vendor-specific devices and protocols.
SDN Controller	A software entity that has exclusive control over an abstract set of data plane resources. An SDN controller may also offer an abstracted information model instance to at least one client. An SDN Controller Translates SDN applications' requirements and exerts more granular control over network elements, while providing relevant information up to SDN applications.
SDO	Standards Development Organization
SD-WAN	An SD-WAN is a Wide Area Network (WAN) managed using the principles of software-defined networking. The main driver of SD-WAN is to lower WAN costs using more affordable and commercially available leased lines, as an alternative or partial replacement of more expensive MPLS lines. Control and management is administered separately from the hardware with central controllers allowing for easier configuration and administration.
Service	Represents the Customer experience of a Product Instance that has been realized within the Service Provider's and / or Partners' infrastructure. (TMF GB922)
Service Component	A segment or element of a Service that is managed independently by the Service Provider.

Term/Abbreviation/ Acronym	Definition
Service Continuity	The continuous delivery of service in conformance with service's functional and behavioral specification and SLA requirements, both in the control and data planes, for any initiated transaction or session till its full completion even in the events of intervening exceptions or anomalies, whether scheduled or unscheduled, malicious, intentional or unintentional. (ETSI)
Service Access Point	The endpoint of a specific Connectivity Service at an Service Interface (e.g., UNI, ENNI).
Service Level Agreement (SLA)	The contract between the Customer and Service Provider or Operator specifying the agreed to service level commitments and related business agreements.
Service Level Specification (SLS)	The technical specification of the service level being offered by the Service Provider to the Customer.
Service Operations, Administration, and Maintenance (SOAM)	Mechanisms for monitoring connectivity and performance for entities (links, services, etc.) within the Carrier Ethernet Network.
SLA	A service-level agreement is an agreement between two or more parties, where one is the customer and the others are service providers. This can be a legally binding formal or an informal "contract" (for example, internal department relationships). The agreement may involve separate organizations, or different teams within one organization. Contracts between the service provider and other third parties are often (incorrectly) called SLAs – because the level of service has been set by the (principal) customer, there can be no "agreement" between third parties; these agreements are simply "contracts." Operational-level agreements or OLAs, however, may be used by internal groups to support SLAs. If some aspect of a service has not been agreed with the customer, it is not an "SLA"
Service Provider	The seller of network services. Defined as a company or organization, making use of an electronics communications network or part thereof to provide a service or services on a commercial basis to third parties (ETSI).
Service Specification	The detailed description of the characteristics and behavior of a Service.

Term/Abbreviation/ Acronym	Definition
SNMP	Simple Network Management Protocol
Synchronous Optical Networking (SONET)	Synchronous optical networking (SONET) and synchronous digital hierarchy (SDH) are standardized protocols that transfer multiple digital bit streams synchronously over optical fiber using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data can also be transferred via an electrical interface. The method was developed to replace the plesiochronous digital hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fiber without synchronization problems.
Stateless v. Stateful packet flow classification	A stateless protocol is a communications protocol in which no information is retained by either sender or receiver. The sender transmits a packet to the receiver and does not expect an acknowledgment of receipt. A UDP connection- oriented session is a stateless connection because the system doesn't maintain information about the session during its life. A stateless protocol does not require the server to retain session information or status about each communications partner for the duration of multiple requests. In contrast, a protocol that requires keeping of the internal state on the server is known as a stateful protocol. A TCP connection-oriented session is a 'stateful' connection because both systems maintain information about the session itself during its life. Examples of stateless protocols include the Internet Protocol (IP), which is the foundation for the Internet, and the Hypertext Transfer Protocol (HTTP), which is the foundation of data communication for the World Wide Web.
STM	Synchronous Optical Networking
Subscriber	The buyer of network services
Subscriber Service Endpoint	The demarcation points for the beginning or end of a NaaS
Switch	A network switch (also called switching hub, bridging hub, officially MAC bridge) is a computer networking device that connects devices together on a computer network, by using packet switching to receive, process and forward data to the destination device. A network switch forwards data only to one or multiple devices that need to receive it, rather than broadcasting the same data out of each of its ports.

Term/Abbreviation/ Acronym	Definition
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
Tenant Domain	The domain that provides VNFs, and combinations of VNFs into Network Services, and is responsible for their management and orchestration, including their functional configuration and maintenance at application level
Transaction Language 1 (TL1)	Transaction Language 1 (TL1) is a widely used management protocol in telecommunications. It is a cross-vendor, cross-technology man-machine language, and is widely used to manage optical (SONET) and broadband access infrastructure in North America. TL1 is used in the input and output messages that pass between Operations Support Systems (OSSs) and Network Elements (NEs). Operations domains such as surveillance, memory administration, and access and testing define and use TL1 messages to accomplish specific functions between the OS and the NE. TL1 is defined in Telcordia Technologies (formerly Bellcore) Generic Requirements document GR-831-CORE.
TLS	Transport-Layer Security
UDP	User Datagram Protocol
Unified Markup Language (UML)	A general-purpose, developmental, modeling language in the field of software engineering that is intended to provide a standard way to visualize the design of a system. (OMG UML)
Use Case	In UML, a Use Case represents one particular type of a system's behavior based on stimuli from an external source (i.e., an actor). A system may have several Use Cases that define all its behavior. (OMG UML)
User Network Interface (UNI)	The physical demarcation point between the responsibility of the Service Provider and the responsibility of the Customer.

Term/Abbreviation/ Acronym	Definition
Virtualization	An abstraction whose selection criterion is dedication of resources to a particular client or application. When the context is general, for example when speaking of virtual network elements (VNEs), the term virtual may be used even when abstract might suffice. Virtual is also sometimes used colloquially to mean non-physical.
Virtual Application (VA)	The more general term for a piece of software which can be loaded into a Virtual Machine. NOTE: A VNF is one type of VA. (ETSI)
Virtualized CPU (vCPU)	A virtualized CPU created for a VM by a hypervisor. NOTE: In practice, a vCPU may be a time sharing of a real CPU and/or in the case of multi-core CPUs, it may be an allocation of one or more cores to a VM. It is also possible that the hypervisor may emulate a CPU instruction set such that the vCPU instruction set is different to the native CPU instruction set (emulation will significantly impact performance). (ETSI)
Virtualized Deployment Unit (VDU)	A construct that can be used in an information model, supporting the description of the deployment and operational behavior of a subset of a VNF, or the entire VNF if it was not componentized in subsets. NOTE: In the presence of a hypervisor, the main characteristic of a VDU is that a single VNF or VNF subset instance created based on the construct can be mapped to a single VM. A VNF may be modelled using one or multiple such constructs, as applicable. (ETSI)
Virtualized Infrastructure Manager (VIM)	A functional block that is responsible for controlling and managing the NFVI compute, storage and network resources, usually within one operator's Infrastructure Domain (e.g. NFVI-PoP) (ETSI)
Virtual Link	A set of connection points along with the connectivity relationship between them and any associated target performance metrics (e.g. bandwidth, latency, QoS). NOTE: The Virtual Link can interconnect two or more entities (VNF components, VNFs, or PNFs) and it is supported by a Virtual Network (VN) of the NFVI. (ETSI)
VM	Virtual Machine. A virtualized computation environment that behaves very much like a physical computer/server. A VM has all its ingredients (processor, memory/storage, interfaces/ports) of a physical computer/server, and is generated by a Hypervisor, which partitions the underlying physical resources and allocates them to VMs. Virtual Machines are capable of hosting a VNF Component (VNFC). (ETSI)
Virtual network	A virtual network routes information among the network interfaces of VM instances and physical network interfaces, providing the necessary connectivity. NOTE: The virtual network is bounded by its set of permissible network interfaces. (ETSI)

Term/Abbreviation/ Acronym	Definition
Virtual Network Element (VNE)	An abstraction representing a set of network functions providing network element capabilities implemented in a virtualized environment.
Virtualized Network Function (VNF)	The implementation of an NF that can be deployed on a Network Function Virtualisation Infrastructure (NFVI)
Virtualized Network Function Instance (VNF Instance)	A run-time instantiation of the VNF software, resulting from completing the instantiation of its components and of the connectivity between them, using the VNF deployment and operational information captured in the VNFD, as well as additional run-time instance-specific information and constraints (ETSI)
Virtualized Network Function Component (VNFC)	An internal component of a VNF, providing a VNF Provider a defined sub-set of that VNF's functionality, with the main characteristic that a single instance of this component maps 1:1 against a single Virtualisation Container (ETSI)
Virtualized Network Function Component (VNFC) Instance:	The instance of a VNFC deployed in a specific Virtualisation Container instance. It has a lifecycle dependency with its parent VNF instance (ETSI)
Virtualized Network Function Descriptor (VNFD)	A configuration template that describes a VNF in terms of its deployment and operational behavior, and is used in the process of VNF on-boarding and managing the lifecycle of a VNF instance (ETSI)
Virtualized Network Function Manager (VNFM)	A functional block that is responsible for the lifecycle management of VNF (ETSI)
Virtualized NIC (vNIC)	Virtualized NIC created for a VM by a hypervisor (ETSI)
VoIP	Voice over IP
Virtual Private LAN Service (VPLS)	Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint to multipoint communication over IP or MPLS networks. It allows geographically dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. The term 'sites' includes multiplicities of both servers and clients. The technologies that can be used as pseudo-wire can be Ethernet over MPLS, L2TPv3 or even GRE. There are two IETF standards track RFCs (RFC 4761 and RFC 4762) describing VPLS establishment.

Term/Abbreviation/ Acronym	Definition
VXLAN	Virtual Extensible LAN
WAN	Wide Area Network
WLAN	Wireless Local Area Network
XML	Extensible Markup Language. A markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable.

SDWAN Expert Boot Camp
Course Overview

Networks are being transformed into software defined, virtualized, orchestrated, and automated networks of the future. SDWAN leverages these technologies and is revolutionizing the telecom industry. Intelligent path selection, application optimization, and policy-based control of network security resources is only the beginning of the implementation challenges awaiting those in charge with "turning-up" the next generation of WAN services.

According to recent industry surveys by Vertical Systems Group and others, there is a critical shortage of ICT professionals skilled in these new technologies to lead this exciting transformation. The Academy's SDWAN Boot Camp is the industry's first and only vendor independent training that teaches the skills required to lead the transformation to the digital future. Choose the path that elevates your career by becoming an expert in SDWAN and SDN/NFV technologies.

The Academy's SDWAN Expert Boot Camp is a comprehensive expert level training program covering SDWAN, SDN, NFV and automated network orchestration platforms.

The course is an immersion into SDWAN and related SDN/NFV technologies and covers the development of these modern network techniques to provide a basis for expert level understand and analysis of these technologies and their applications.

We've applied our MEF-CECP Boot Camp award-winning course design to SDWAN technologies to prepare the next generation of telecommunications professionals. Available as an accelerated 3-day Boot Camp course, the training covers all the material to prepare you for both the MEF-SDCP (SDWAN) and MEF-SNCP (SDN/NFV) Professional Certification exams.

Course Description

The Academy's SDWAN Boot Camp course is the only vendor-neutral technical

training course that covers all aspects of Software Defined Wide Area Networks (SDWAN) and the related concepts of Software Defined Networking (SDN) and Network Function Virtualization (NFV). The course will guide your path to becoming an expert in SDWAN and the underlying technologies and prepare you to take and pass both the MEF-SDCP and MEF-SNCP certification exams.

The course combines lecture of SDWAN and related technologies, with practical exercises that tie the theory to real-world applications. The course also includes quizzes for each of the modules to assess each student's mastery of the material, along with a post course practice exam that provides students with a final test prior to taking the MEF certification exams. Offered as a 3-day accelerated boot camp style course, the training is a vendor independent deep dive into all aspects of SDWAN including all the topics in the MEF-SDCP and MEF-SNCP Exam Blueprint A, and related topics that will be covered in upcoming versions of the MEF professional certifications.

Course Outline

Introduction to Software Defined WAN (SDWAN)

This introductory lecture presents the SDWAN ecosystem and explains how the convergence of several modern networking trends including Software Defined Networking and automated provisioning called Orchestration have resulted in a new genre of networking technology. The lecture provides the background of each of these important areas of innovation and sets the stage for an in-depth look at each as the course unfolds.

•   Introduction to SDWAN Architecture and components
•   SDWAN is one of the first solutions of Software Defined Networking
•   Technology Vectors Contributing to SDWAN
•   The Journey to SDWAN

Module 1 - Software Defined Networking

This lecture presents a comprehensive overview of Software Defined Networking (SDN). It discusses the technical and economic problems that created an opportunity for academic and commercial proponents to form the Open Network Foundation and forge an open, standards-based environment for the development of a new era of networking technology. The architectural advantages of a centralized control system with distributed forwarding elements is presented to introduce the concept of "smart" controllers and "simple/fast/cheap" switches. The lecture introduces the OpenFlow protocol

which was
the first industry-developed language that enables a central control function to
update the forwarding tables, Ethernet and/or IP. The lecture also discusses
the challenges of legacy-device (non-OpenFlow capable) integration and
exposes several security concerns that need to be mitigated to ensure a secure
environment.

- Overview of Software Defined Networking
- SDN Architecture and Interfaces
- SDN Implementation Models (native, overlay, hybrid)
- SDN Controllers – OpenDaylight from Hydrogen to Neon
- Incorporating Non-OpenFlow capable devices using NetConf/YANG
- Troubleshooting and security considerations

Module 2 - Network Function Virtualization

With an expert level understanding of Software Defined Network architectures
and components, the course turns its attention to Network Function
Virtualization (NFV), or the ability to create a shared hardware resource pool
that can be used to flexibly run module software programs that perform various
network functions. The lecture first explains virtualization techniques that have
been developed over the past 50 years for mainframes, multi-user PCs and
within data centers.

Next the ETSI NFV framework or architecture is explained along with key
interfaces, called reference points by ETSI, between the various components
required to manage the instantiation and lifecycle of the software elements
running on the virtual (or shared) infrastructure.

- Introduction to Virtualization – From Main Frames to Data Centers
- The ETSI NFV Architecture and Reference Points (APIs)
- How NFV Leverages the Modularity of SDN designs
- Virtualizing Network Functions
- Service Function Chaining and Forwarding Graphs
- NFV Management and Operations (MANO)
- Migration Strategies for Implementing Virtual Network Functions
(VNFs)
- Proof of Concept (PoCs) and TestFest Status/Results

Module 3 - Network Automation & Orchestration

This lecture introduces Orchestration platforms and discusses their evolution
from legacy Operation Support Systems (OSS), to automated provisioning

systems that streamline the service turn-up and resource management required to host new services. Originally invented to help data center operators meet the need for rapid deployment of computing resources, Orchestration platform capabilities have merged with network controller and network management systems. The Orchestration platform is where requests are mapped to resources in a policy-defined manner. The lecture also highlights the work of MEF in Orchestration interfaces (APIs) and discusses the interoperability of the MEF LSO APIs with other industry automation initiatives.

- Network Automation and Orchestration
- Software Orchestration Concepts
- Orchestration Automation Platforms
- Linux Foundation ONAP Releases
- MEF LSO Orchestration Application Programming Interfaces (APIs)
- Survey of Tools and Applications

Following the completion of Modules 1, 2 and 3 students are prepared to take the MEF-SNCP (SDN/NVF) certification exam.

Module 4 - SDWAN Implementations and Standards

The capstone lecture in the course revisits the SDWAN application now that students have an expert level understanding in the components and functionality of typical SDWAN solutions, and understand the background and evolution of the technology initiatives that have now merged together. The lecture presents several user stories and scenarios and shows how SDWAN can provide significant benefits in terms of cost reduction, resiliency and address capacity constraints. A summary of popular SDWAN solutions is discussed, underscoring the challenges to open SDWAN interoperability due to the lack of standards and the proprietary nature of early products.

The MEF 70 SDWAN standard – The industry's first SDWAN standard, is dissected and explained so that students will have a detailed understanding of the developing "common language" of SDWAN componentry and functionality.

- SDWAN Solution Architectures
- MEF 70 The First SDWAN Standard
- SDWAN Underlay Network Connectivity Services (UCS)
- Service Delivery and Traffic Engineering – The SDWAN Edge
- Virtual Tunnel/Path Selection
- Survey of Popular Vendor SDWAN Approaches, Solutions and Products
- Emerging Opportunities for Dynamic Service Delivery using SDWAN

SASE – Secure Access at the Service Edge

This "bonus" lecture, not yet covered on the MEF-SNCP or MEF-SDCP certifications, is provided to give students a look into the future of security solution being developed for the SDWAN environment. SDWAN, like other SDN and distributed networking solutions, introduces a number of security issues that need to be addressed. The emerging trend of SASE is discussed to show how a holistic, policy-based approach to security nicely complements an SDWAN deployment.

• Adding Security to the SDWAN Solution
• Understanding the components and requirements of the security portfolio
• MEF SASE Standardization Efforts
• Defining the User Story, Use Cases and Implementation Requirements
• The Benefits of a Comprehensive, Policy-based Security Implementation
• Emerging Opportunities for SASE Implementations

SDWAN Expertise is the Path to Success

The Academy's SDWAN Boot Camp is the latest and most up-to-date, expert level SDWAN training program. The course provides a network-centric view to the underlying SDN, NFV and Orchestration technologies used to deliver an automated SDWAN application. The course goes well beyond simple exercises based on the Mininet SDN emulator. The Academy's SDWAN Boot Camp explains the technologies and the solutions that will usher in the next generation of digital networks. The course provides the depth and context necessary to understand the details of the technical aspects of the individual vendor solutions that you may be evaluating so you can make informed decisions as an SDWAN expert.

Upon completion of the SDWAN Expert Boot Camp course, students will be able to:

Module 1 : Software Defined Networking (SDN)

- Describe the SDWAN architecture and the functionality of each of the components.

- Understand common use cases for SDWAN and select a specific solution to meet a given application scenario.

- Have in-depth understanding of the technologies used in Software Defined Networking including SDN Architecture, Interfaces, and Implementation Models.

- Know the functions and purpose of an SDN controller within the overall SDN architecture and be able to list the features and advantages of the marketing leading OpenDayLight SDN Controller.

- Incorporate Non-OpenFlow capable devices using non-OpenFlow programmatic methods including NetConf/YANG or other protocol adapters and provisioning interfaces.

Module 2 – Network Function Virtualization (NFV)

- Understand computer virtualization and be able to describe the advantages and disadvantages of various virtualization techniques.

- Be aware of the inter-process communication requirements and the potential for increased latency among virtualized applications and

suggest technologies and implementation strategies to mitigate excessive latency.

- Describe the ETSI Network Function Virtualization standardization effort.

- Describe the ETSI NFV model, functional blocks including Management and Orchestration (MANO) and list the important Reference Point / interfaces between functional components.

Module 3 – Orchestration

- Understand the goals and potential benefits of network service provisioning automation or orchestration.

- List the lifecycle service automation process and each step from design to termination.

- Describe the landscape of current orchestration platforms and projects and be aware of the maturity and market take-up of the most popular.

Module 4 – SDWAN

- Possess and in-depth knowledge of SDWAN solution architectures.

- Understand the definitions and purpose of MEF 70 - The First SDWAN Standard.

- Describe the differences in SDWAN Underlay Network Connectivity Services (UCS).

- Understand the importance of Service Delivery and Traffic Engineering at the SDWAN Edge and how to specify appropriate Virtual Tunnel/Path Selection.

- List emerging opportunities for dynamic WAN service selection.

Module 5 – Secure Access at the Service Edge

- Understand the importance of securing the SDWAN Service Edge.

- Understand the typical components and requirements of an effective security portfolio.

- Describe the MEF SASE Standardization Efforts.

- Be familiar with the popular User Stories, Use Cases and Implementation Requirements.

- Describe the emerging opportunities for SASE-based security implementations.

Course Audience

Networking Professionals who desire an in-depth understanding of SDN/NFV, orchestration and SD-WAN applications. Professionals engaged in network architecture, engineering, design and deployment, along with Technical Sales and Marketingengineers whoarticulate andpresentthecapabilitiesoftheirownnetworks to partnersandcustomerswillallbenefitfromtheexpertiseinSDWANthat thiscourse delivers

ThiscourseisacomprehensivesupersetofboththeONFSDNProfessional andMEF-NF professionalcertificationsandcoversallthetopicslistedon theexam"BluePrints". The SDWAN Academy has worked in close collaboration with MEF on the development and launchofthe MEF-SDN/NFV certificationandourexpertinstructorswhowillfacilitatethe courses have all passed the exam with highmarks.

Become an Expert!

MEF-SDWAN Exam Blueprint (Sept. 2019)

	Section/Objective	Percentage Weights
1	**Assessing, Planning and Designing**	**25%**
1.01	Given a scenario, size and scale an SD-WAN solution	
1.02	Given a set of business requirements, assess application criticality and demand	
1.03	Given a scenario, recommend and justify an SD-WAN strategy based on customer strategy	
1.04	Given a scenario, determine integration requirements for a new SD-WAN network into an existing infrastructure	
1.05	Compare and contrast infrastructure and operational benefits of SD-WAN with legacy solutions	
2	**Implementation**	**45%**
2.01	Based on business requirements, define Application Flows based upon MEF 70 standard Application Flow criteria	
2.02	Based on business requirements, define and map Policies based upon MEF 70 standard Policy criteria	
2.03	Select appropriate Underlay Connectivity Services for an SD-WAN network based on the types and characteristics of available options	
2.04	Given a scenario, recommend a migration strategy from existing infrastructure to new SD-WAN service	
2.05	Determine IP subnet and address requirements at an SD-WAN subscriber site	
2.06	Determine security requirements for an SD-WAN service	
3	**Lifecycle Orchestration**	**15%**
3.01	Identify common service impacting issues, diagnostic toolsets, and diagnostic actions	
3.02	Based on application requirements, determine the metrics for assessing service performance	
3.03	Given a scenario, troubleshoot performance issues with an SD-WAN service	
4	**Components and Features**	**15%**
4.01	Define the fundamentals and characteristics of an SD-WAN solution according the MEF 70 standard	
4.02	Demonstrate knowledge of the MEF 70 components and the functions of SD-WAN service components and Service Attributes	
	Total	**100%**