SDN and NFV Overview

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1.1 SDN Overview

1.1.1 Evolution of the Computer Era

1.1.1.1 Mainframe to PC Transition

- `IBM System/360` : Beginning of mainframes with centralized architecture.

> Mainframes are powerful, large-capacity computers designed for handling and processing vast amounts of data for numerous users simultaneously in a centralized manner.

IBM

It's like having one really big brain that many smaller computers or users can tap into to get their various jobs done, from processing bank transactions to handling airline reservations.

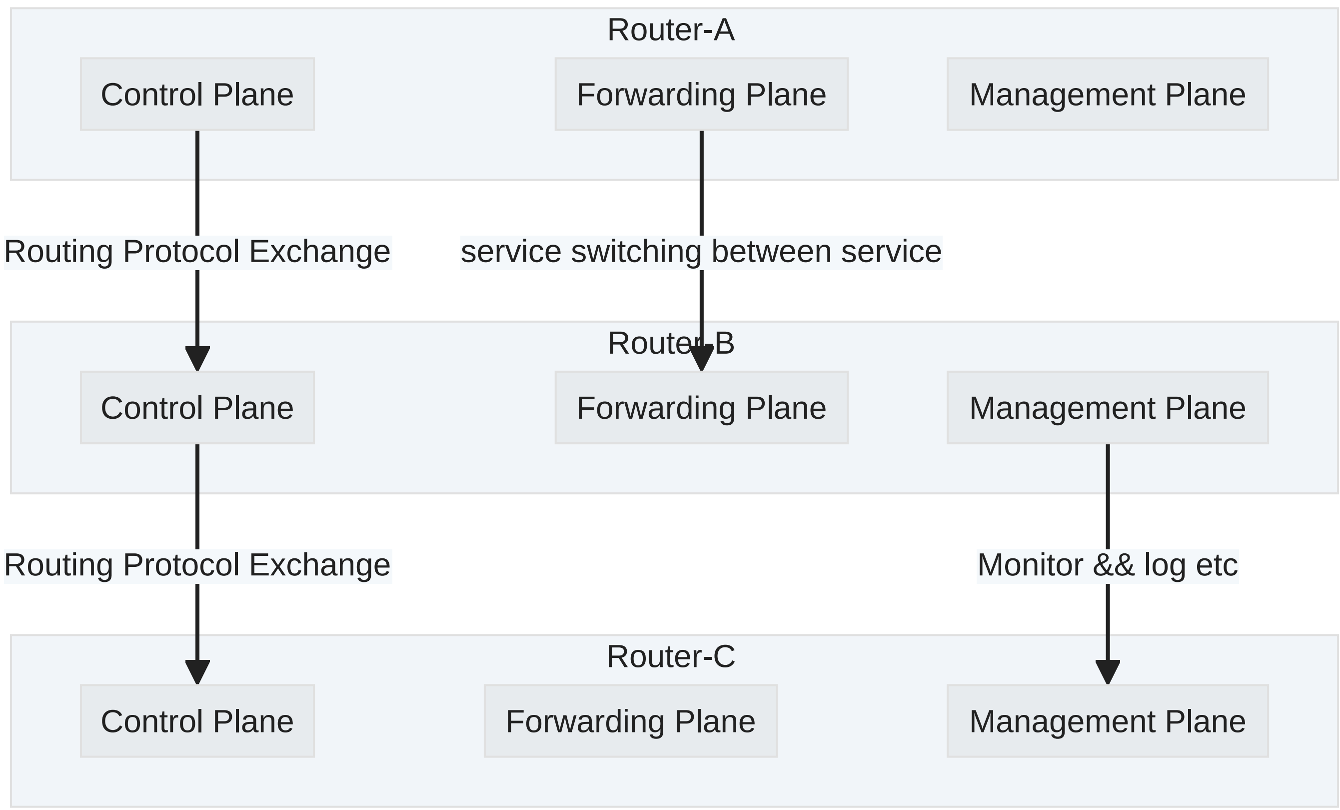
- PCs introduced hardware innovations, OS development, and application changes.
- Three factors contributed to PC ecosystem rapid innovation:
  - Hardware substrate (x86 instruction set)
  - Software-defined upper-layer applications
  - Open-source model (Linux)

1.1.1.2 Network Industry Development

> Reflecting on IT industry transformations, the network industry proposes SDN and aims for more open, flexible networks.

1.1.1.3 Current Situation in Network Industry

1.1.1.3.1 Typical IP Network Structure



- Distributed network with peer-to-peer control.

> A distributed network with peer-to-peer control is a type of computer network where each participant (peer) can communicate directly with others and share resources without needing a central server.

- **Benefit:** Different suppliers' products work together and are reliable.

1.1.1.3.2 Challenges in Typical Networks

1.1.1.3.2.1 Frequent Network Congestion

Problem with Solution's

1. **Problem**: In networks, the shortest path routing often neglects bandwidth availability, leading to congested routes and packet loss. For

instance, router C's direct route to D may be the shortest but could lack sufficient bandwidth for traffic demands.

- **Solution**: To optimize network efficiency, routing algorithms should factor in link bandwidth usage. This approach would balance the load by potentially rerouting traffic through underutilized paths with adequate bandwidth, such as going from C to A, then A to D, ensuring a smoother data flow.

2. **Problem**: Tunnel creation in networks can fail if it's based on a fixed sequence that does not account for live bandwidth conditions. For example, when Tunnel 3 from C-H is set up without considering current network load, it might encounter a bottleneck.

    - **Solution**: Tunnels should be established using a dynamic selection process that evaluates real-time bandwidth. If the preferred path for Tunnel 3 lacks capacity when needed, the system should identify alternative routes or postpone tunnel establishment until the network can accommodate the additional traffic.

1.1.1.3.2.2 Complex Technologies

- Increasing complexity with many protocols and commands to learn.

1.1.1.3.2.3 Difficult O&M (Operations & Maintenance)

> Too dependent on manual fault identification leads to delayed responses. Preventive analysis is lacking.

1.1.1.3.2.4 Slow Service Deployment

Traditional Method

- Traditional network policy changes are complex and not user-friendly.
- Adding a new network service is slow and requires widespread manual adjustments.
- Physical networks lack automatic setup, demanding hands-on configuration for every device.

The improved process aims for:

- Devices can move around the network without problems if they follow the rules.
- New services can be launched rapidly with minimal manual setup.
- Zero Touch Provisioning enables new devices to self-configure upon connection to the network.

1.1.2 SDN (Software-Defined Networking) Overview

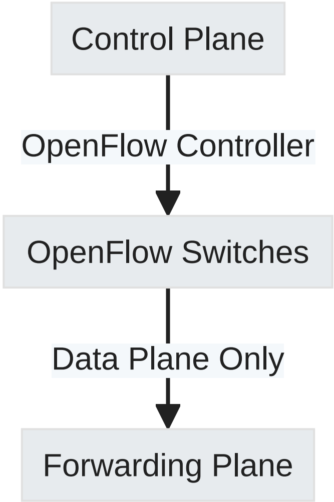
1.1.2.1 Origin

- Developed by Clean Slate Program at Stanford University.
- Aims to separate control and data planes for centralized control.

1.1.2.2 Characteristics

- Forwarding-control separation.
- Centralized control.
- Open programmable interfaces.

1.1.2.3 Core Concept



1.1.2.4 SDN Applications

1.1.2.4.1 Control Plane Functions

- Provided by the controller (e.g., OpenFlow controller).

1.1.2.4.2 OpenFlow Protocol

1.1.2.4.2.1 Message Types

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1. **Controller-to-Switch:** Manage/query switch info.

> Like modify Configuration ,Modify-State etc

2. **Asynchronous:** Initiated by switch upon status change.

3. **Symmetric:** Can be initiated by both switch and controller (e.g., Hello, Echo, Error messages).

Packet details

- **Hello:** A greeting message to establish communication between devices.
- **Echo:** A request and response to confirm connectivity.
- **Error:** Notification of problems encountered during communication or processing.

1.1.2.4.3 Flow Table Overview

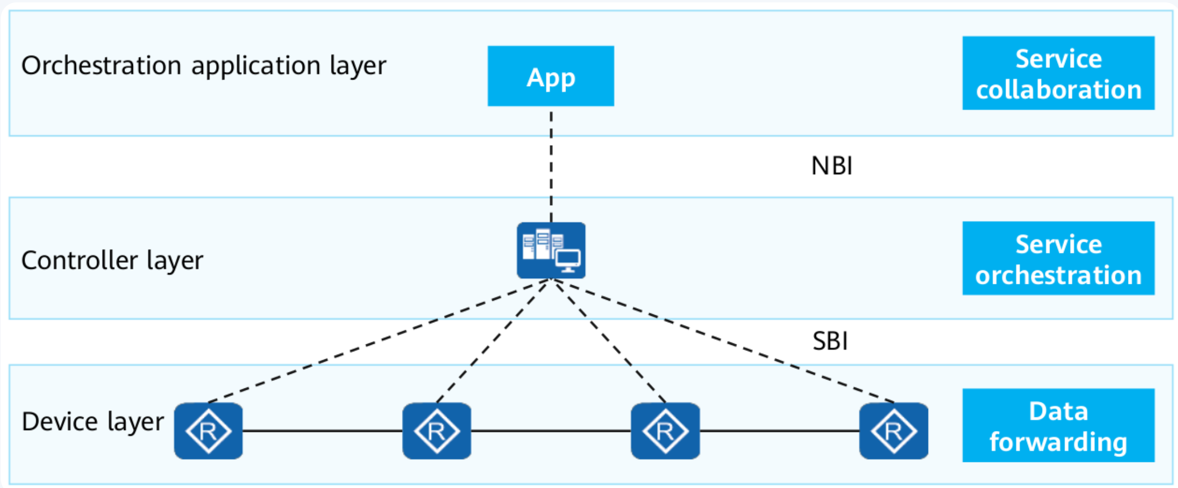
	Field
Match Fields	Criteria used to match incoming packets (e.g., source IP, destination IP, TCP/UDP ports).
Priority	Determines the order in which flow entries are considered. Higher priority entries are checked first.
Counters	Track how many packets and bytes have hit a particular flow entry.
Instructions	Actions to take when a packet matches the entry (e.g., forward, modify, drop).
Timeouts	Determine how long a flow entry remains active in the absence of matching packets (Idle) or unconditionally (Hard).
Cookie	A unique identifier for the flow entry set by the controller.
Flags	Additional settings that control various aspects of flow entry behavior (e.g., overwrite protection).

> OpenFlow switches forward packets based on flow tables.

Difference Routing table VS Flow table

- A routing table guides a router on where to send packets next based only on their destination IP address, Routing table entries are derived from routing protocols among devices, with packets routed using the longest match rule, and a device maintains a single routing table.
- A flow table in an OpenFlow switch allows for multifaceted packet handling, directing actions based on diverse criteria including multiple packet fields(like source IP, destination IP, TCP/UDP ports, etc.), Flow tables, created by an OpenFlow controller, are dynamic in length and detail match-forward criteria, with a network device hosting multiple flow tables.

1.1.2.5 Huawei SDN Network Architecture



1.1.2.5.1 Layers

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1. **Orchestration Application Layer:** Higher-level services like OSS and OpenStack.

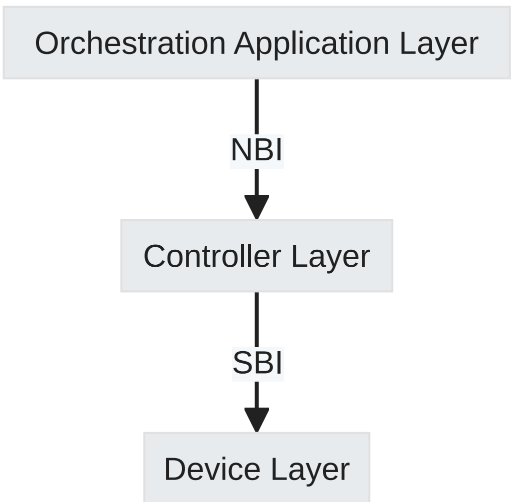
> - **OSS (Operational Support System):** refers to software used by telecommunications service providers to manage their networks and

> services
> - **OpenStack:** is an open-source cloud computing platform for creating and managing large groups of virtual private servers in a data center.

2. **Controller Layer:** Brain of the SDN system; implements network service orchestration , decision-maker that manages and directs network traffic by telling network devices how to handle data packets.
3. **Device Layer:** Performs forwarding based on controller instructions.

1.1.2.5.2 Interfaces

- **NBIs (Northbound Interfaces):** RESTful, used between orchestration(app) layer and controller layer.
- **SBIs (Southbound Interfaces):** Protocols like NETCONF, SNMP, OpenFlow used between device layer and controller layer.



1.1.2.6 Huawei SDN Solution

> Huawei's approach integrates Management, Control, and Analysis to build Intent-Driven Networks across various domains such as DC Fabric,

> Campus Networks, and Branch Interconnection (SD-WAN).

> **TIP**
>
> - **Cloud platform:** A system that controls networking, processing power, and data storage in a data center, with OpenStack being a popular open-source option.
> - **Element Management System (EMS):** A software that handles operations for specific types of telecom equipment.
> - **Orchestration (container orchestration):** Software like Kubernetes that manages and organizes containers, which are lightweight virtual environments for running applications.
>
> > A container bundles an application with all its necessary components to ensure it works consistently across different computing environments.
>
> - **MTOSI/CORBA:** Standards used to integrate with Business Support Systems (BSS) or Operational Support Systems (OSS) in telecommunications.
> - **Kafka/SFTP:** Technologies used to transfer data securely to big data platforms; Kafka is for real-time data streaming, while SFTP is for secure file transfer.

1.1.2.7 iMaster NCE (Network Cloud Engine)

A platform that integrates management, control, analysis, and AI capabilities.

Features:

1. AI-based analysis for prediction/troubleshooting.
2. Unified database with full lifecycle management capabilities.
3. Autonomous Driving Network System integrating NMS (Network Management System), controllers, analyzers.

Applications:

1. Data Center Networks - iMaster NCE-Fabric
2. Enterprise Campus - iMaster NCE-Campus
3. WAN & Transmission - iMaster NCE-WAN/T/IP

1.1.2.7.1 Simplified Deployment

- Service intent self-understanding and conversion.
- Network change simulation eliminates human errors.

1.1.2.7.2 Intelligent Operations & Maintenance (O&M)

- **Rapid Fault Detection**: Knowledge graph and expert experience.
- **Fast Fault Rectification**: Expertise and simulation analysis.

1.1.2.7.3 Real-time Optimization

> Real-time AI-Fabric-oriented local traffic inference and model optimization.

1.1.2.7.4 Simplified ZTP (Zero Touch Provisioning) Deployment Process

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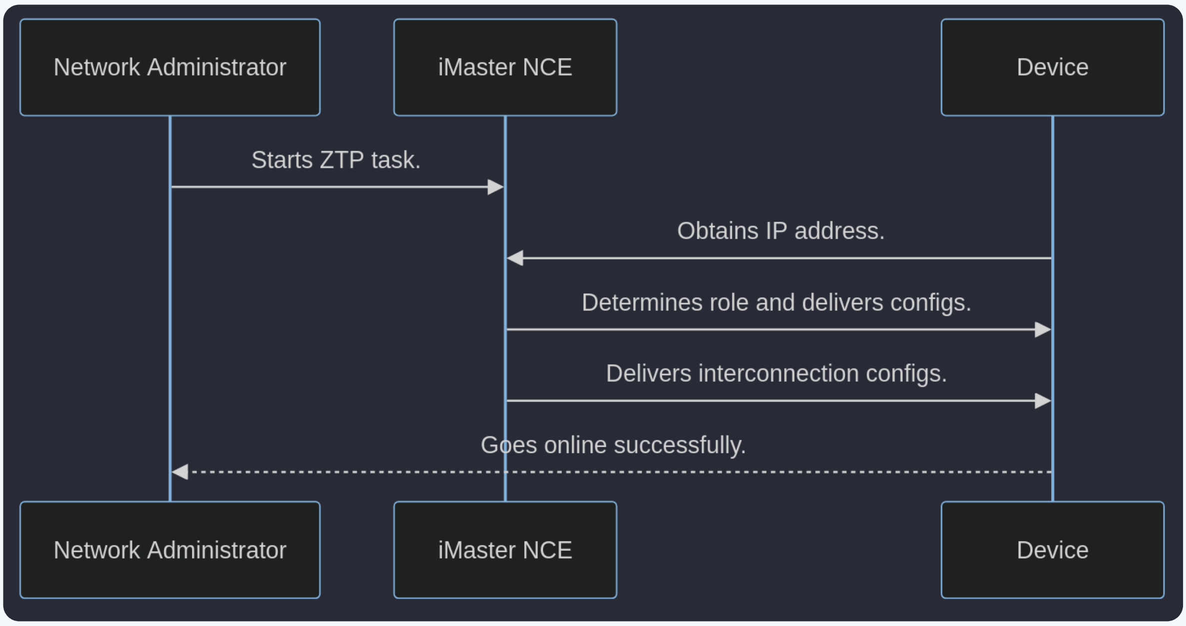


1.1.2.7.5 Fast Service Deployment with iMaster NCE-Fabric

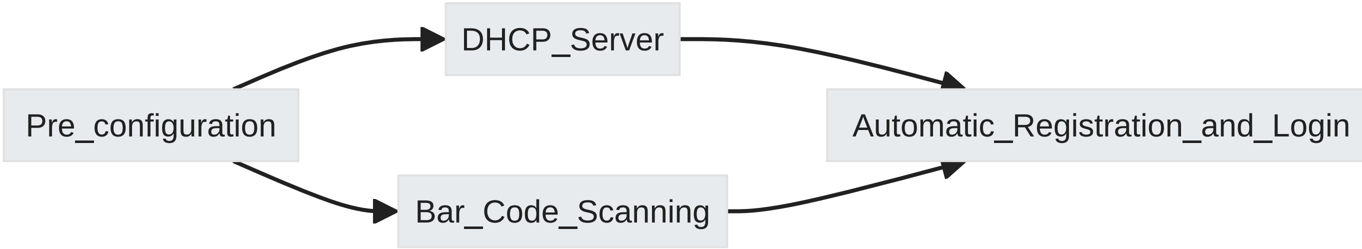
1.1.2.7.5.1 Workflow for Service Deployment

1. Determine the specific requirements and settings for the service deployment.
2. Configuration Delivery through NETCONF

1.1.2.7.5.2 Network Change Simulation and Risk Prediction

- **Resources Sufficiency**: Validates live network resources during changes.
- **Access Connectivity**: Ensures network integrity post-change.

1.1.2.7.5.3 Plug-and-Play Device Deployment Techniques



> Different ways that new devices can be quickly added to networks with minimal effort required from people setting them up – plug them in

1.1.2.7.5.4 Security Group Policies for Free Mobility

> Free mobility ensures consistent network rights regardless of user location or IP address`

1.1.2.7.5.5 Converged Wired and Wireless Management (Native AC)

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construction modes

Standalone AC Mode:

- A single device manages the Wi-Fi network but can get overwhelmed, leading to potential network issues.

Independent AC Mode:

- A card is added to a switch for Wi-Fi control, with separate management for wired and wireless networks.

Wired and Wireless Convergence (Native AC):

- The switch itself can handle both wired and Wi-Fi networks, reducing bottlenecks and simplifying management.

1.1.2.7.6 AI-Powered Intelligent O&M of Campus Networks

> Shifting from focusing on the machines themselves to prioritizing the user's experience, by using advanced data collection methods (elemetry-based second-level data collection.) like remote sensors to gather more detailed information about how systems are functioning.

1.1.2.7.7 AI-Powered Intelligent Radio Calibration

> AI-powered radio calibration helps wireless networks work better by continuously adjusting settings in real-time for optimum performance without needing a human to manually intervene.

1.2 NFV Overview

1.2.1 Origin of NFV

> - Initiated by top carriers in October 2012 with the release of an NFV White Paper.
> - ETSI NFV ISG founded to define network virtualization requirements and system architecture.

1.2.1.1 Standard Organizations

- `ETSI NFV ISG` : Formulates requirements and functional frameworks.
- `3GPP SA5` : Focuses on virtualization management (MANO-related).
- `OPNFV` : Provides an open-source platform to accelerate market adoption.

1.2.2 NFV Value Proposition

1.2.2.1 Benefits for Carriers:

> - **Shortened service rollout time**: Carriers can introduce new services to customers faster.
> - **Reduced network construction cost**: Carriers can build networks more cheaply.
> - **Improved network O&M (Operations & Maintenance) efficiency**: Carriers can manage and fix their networks more easily and quickly.
> - **Open ecosystem**: Carriers can work with a variety of equipment and software providers, leading to more choices and flexibility.

1.2.3 Key Technologies

1.2.3.1 Virtualization

> **NFV (Network Function Virtualization)**, allows network services that used to require dedicated hardware to run as virtual machines on general-purpose servers.

- **Features:**

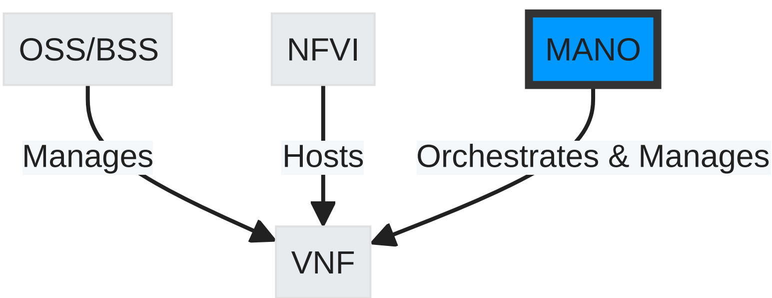
- **Partitioning:** Dividing a physical server into multiple virtual machines that can operate independently.
- **Isolation:** Each virtual machine is kept separate so that the activities in one do not affect others.
- **Encapsulation:** Wrapping up a network function within a virtual machine so that it contains all necessary components and can be easily moved or managed.
- **Hardware Independence:** NFV allows these network functions to run on different types of physical servers, not tied to any specific hardware brand or configuration.

1.2.3.2 Cloudification

Characteristics as defined by NIST:

1. On-demand self-service.
2. Broad network access.
3. Resource pooling.
4. Rapid elasticity.
5. Measured service:a pay-per-use or charge-per-use model.

1.2.4 Introduction to NFV Architecture



1.2.4.1 Layers of Architecture:

1. `OSS/BSS` : These are systems used by telecom companies to support various processes such as managing the network (OSS for Operational Support Systems) and handling billing, customer relations, and business processes (BSS for Business Support Systems).
2. `NFVI` : The Network Functions Virtualization Infrastructure is like a virtual foundation in cloud computing that provides basic resources such as computing power, storage, and networking capabilities. It uses standard servers and cloud management software (CloudOS) to create these resources.
3. `VNF` : A Virtual Network Function is a way to run network services that traditionally required dedicated hardware (like routers or firewalls) as software applications on top of NFVI like VM.
4. `MANO` : This stands for Management and Orchestration. It's an overarching framework in charge of organizing, setting up, and maintaining various components in NFV environments:
    - NFVO: Network Functions Virtualization Orchestrator manages the overall functioning and deployment of network services.
    - VNFM: VNF Manager handles the lifecycle management of VNF instances.
    - VIM: Virtualized Infrastructure Manager manages the interaction with the infrastructure resources like compute, storage, and network.

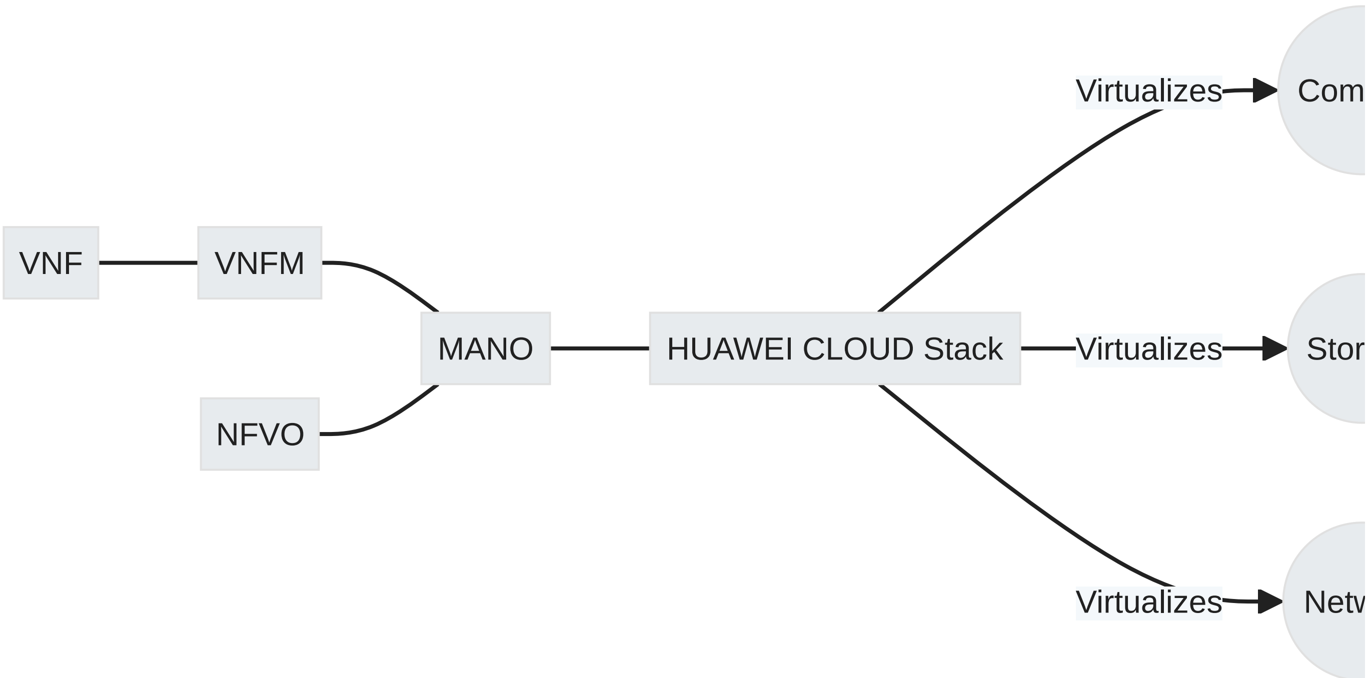
1.2.5 Standard NFV Architecture by ETSI

1.2.5.1 Reference Points:

- `Vi-Ha` , `Nf-Vi` , `Ve-Vnfm` , etc.: Interfaces between different components like VIM, VNFM, VNFs, and hardware.

Reference Point	Description
Vi-Ha	VMs deployment compatibility with NFVI
Nf-Vi	Management of virtual systems within NFVI
Ve-Vnfm	Lifecycle management interface between VNFM and VNF

1.2.6 Huawei's Approach to NFV Solution



- HUAWEI CLOUD Stack implements functions of virtualization layer and VIM.
- Offers solutions for various carriers' networks like wireless, transport, core networks.