

# How Future Networks will be Virtualized

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A satellite view of Earth at night, showing city lights and a space station structure in the foreground. The image is dark, with the Earth's surface illuminated by city lights, creating a glowing pattern of orange and yellow. A large, white, cylindrical structure, likely a space station module, is visible in the upper right corner, with a grid-like structure extending from it. The overall scene is set against the blackness of space.

**How will our world look like in 2050?**



# Would Technology Singularity Signal the Start of Human Immortality from 2045?

## 1 The accelerating pace of change ...



## 2 ... and exponential growth in computing power ...

Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

### COMPUTER RANKINGS

By calculations per second per \$1,000

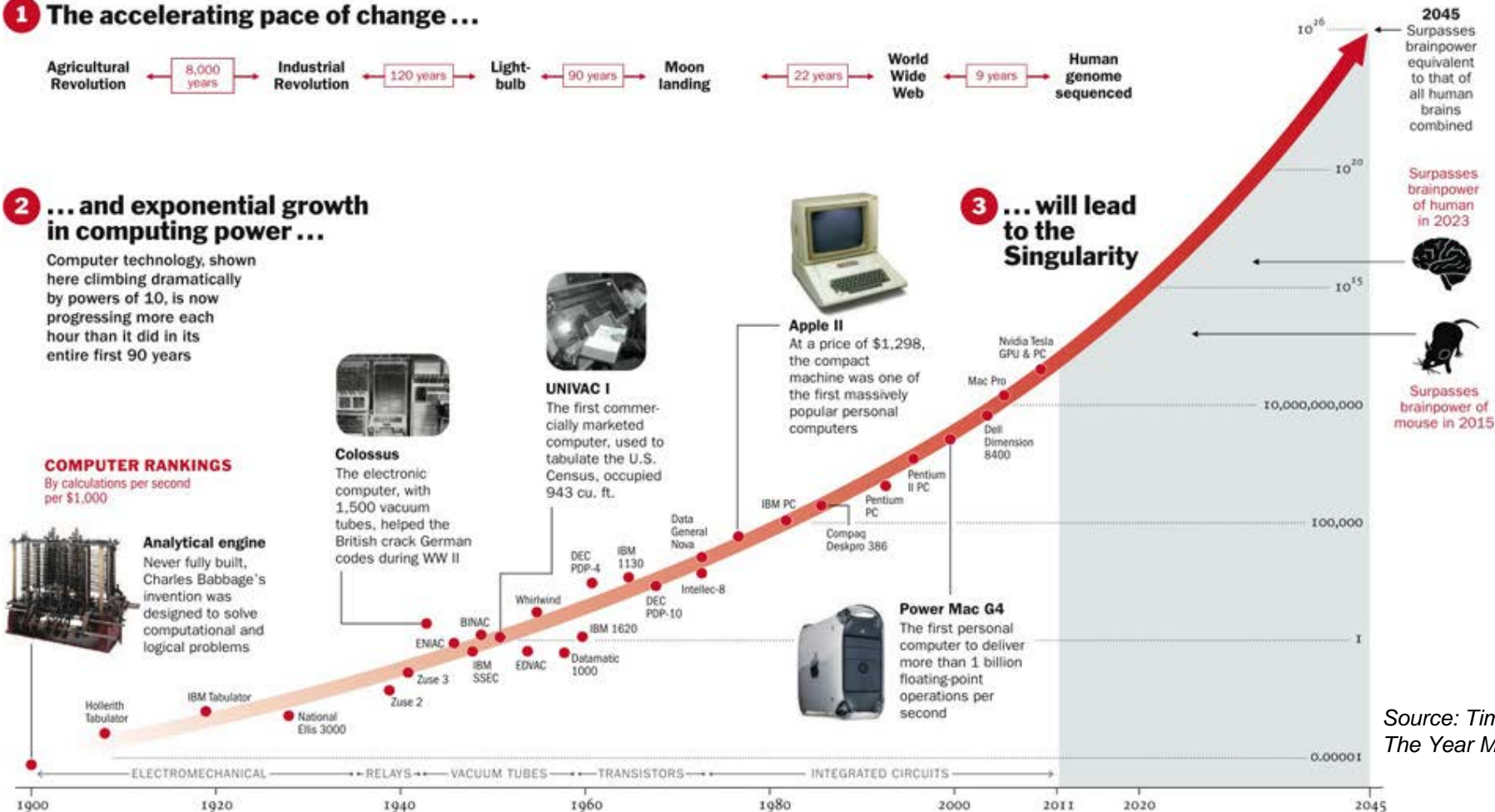
**Analytical engine**  
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems

**Colossus**  
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II

**UNIVAC I**  
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.

**Apple II**  
At a price of \$1,298, the compact machine was one of the first massively popular personal computers

**Power Mac G4**  
The first personal computer to deliver more than 1 billion floating-point operations per second



Source: Time Magazine, February 21, 2011  
The Year Man Becomes Immortal

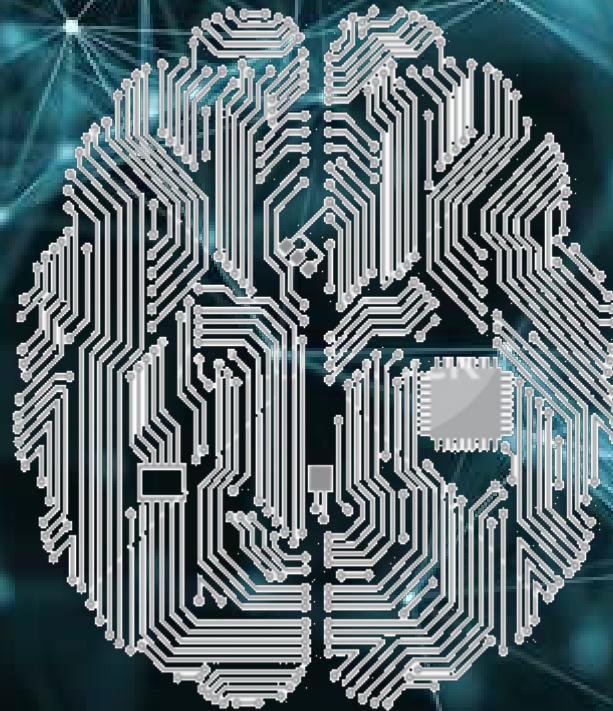
“Technological Singularity is the hypothesis that the invention of **Artificial Superintelligence** will abruptly trigger runaway technological growth, resulting in unfathomable changes to human civilization”

# Artificial Super-Intelligence Impact on Humanity

**“An upgradable intelligent agent (such as a computer running software-based artificial general intelligence) could enter a 'runaway reaction' of self-improvement cycles, with each new and more intelligent generation appearing more and more rapidly, causing an intelligence explosion and resulting in a powerful superintelligence that would, qualitatively, far surpass all human intelligence”**



Humans can  
predict the future



Extraordinarily long  
life expectancy



# We Are All Involved in Humanity's Next Evolution: 5G, NB-IoT, SDN and NFV Provides the Building Blocks for Technology Singularity

VR/AR...



Factory Automation...



Gbps Internet...



Smart Cities...



Mission Critical...



Autonomous Vehicles...



4K/8K OTA...

A.I. Usage in Orchestration...

Cognitive Analytics...

Connectivity

The 5G/IoT Use Cases that are going to be successful will be the ones that improves human lives...





# 5G Cellular V2X (Vehicle-to-Anything)

## Autonomous Driving Eliminates Traffic Accidents and Fatalities



V2X

Vehicle-to-infrastructure (V2I)

e.g. traffic signal timing / priority



Vehicle-to-network (V2N)

e.g. real-time traffic / routing, cloud services



Vehicle-to-vehicle (V2V)

e.g. collision avoidance safety systems



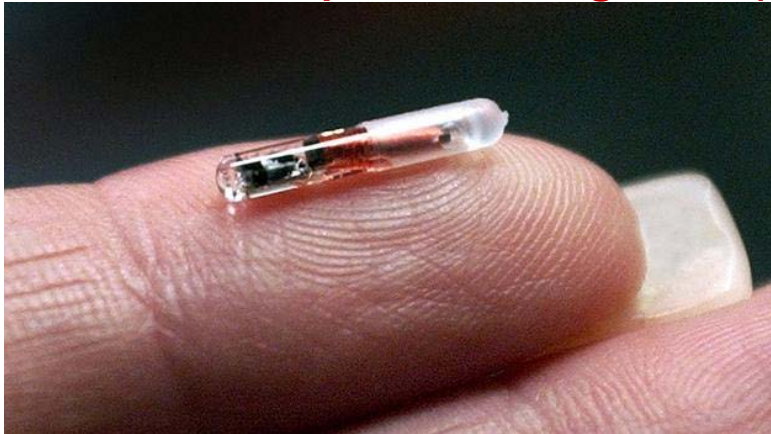
Vehicle-to-pedestrian (V2P)

e.g. safety alerts to pedestrians, bicyclists





# 5G Ultra-Reliable Low Latency Industrial IoT: **Constant Monitoring** Coupled with Medical Science Advancements (*Leveraging Artificial Super-Intelligence*) Prevents or Eliminates Diseases



Ingested Sensors and Implanted Chips



Genome Sequencing Decoded With Artificial Super-Intelligence



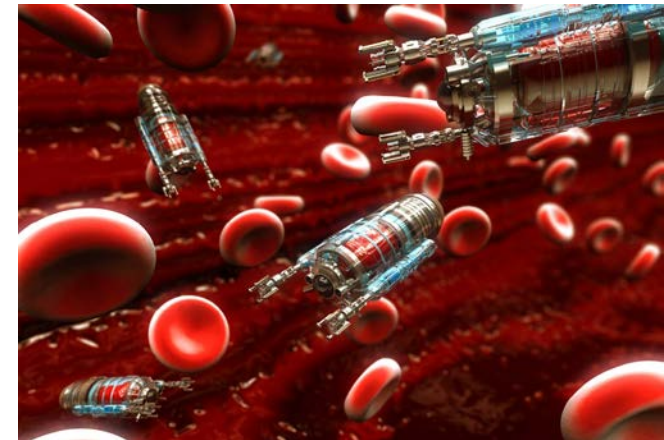
Surgical Robots



Remotely Administered Virtual Reality Surgical Procedures



Cognitive Artificial Intelligence Assisted Health Monitoring



Nanobots in Bodily Fluids for Drugs Delivery or Medical Relief in a Highly-Targeted Way



# 5G Massive Machine Type Communications IoT: Remote Control Drones Improves Physical Security & Eliminate Threats



**Unauthorized Entry**



**NAME**  
Remus Tan

**SEX**  
M

**57168492 Auth Mized Entry**

**ADDRESS**  
89034 Broadway St, Edgar Springs,  
MO 65462

**DATE OF BIRTH**  
30/ 10/ 1991

**T974186498 Auth**

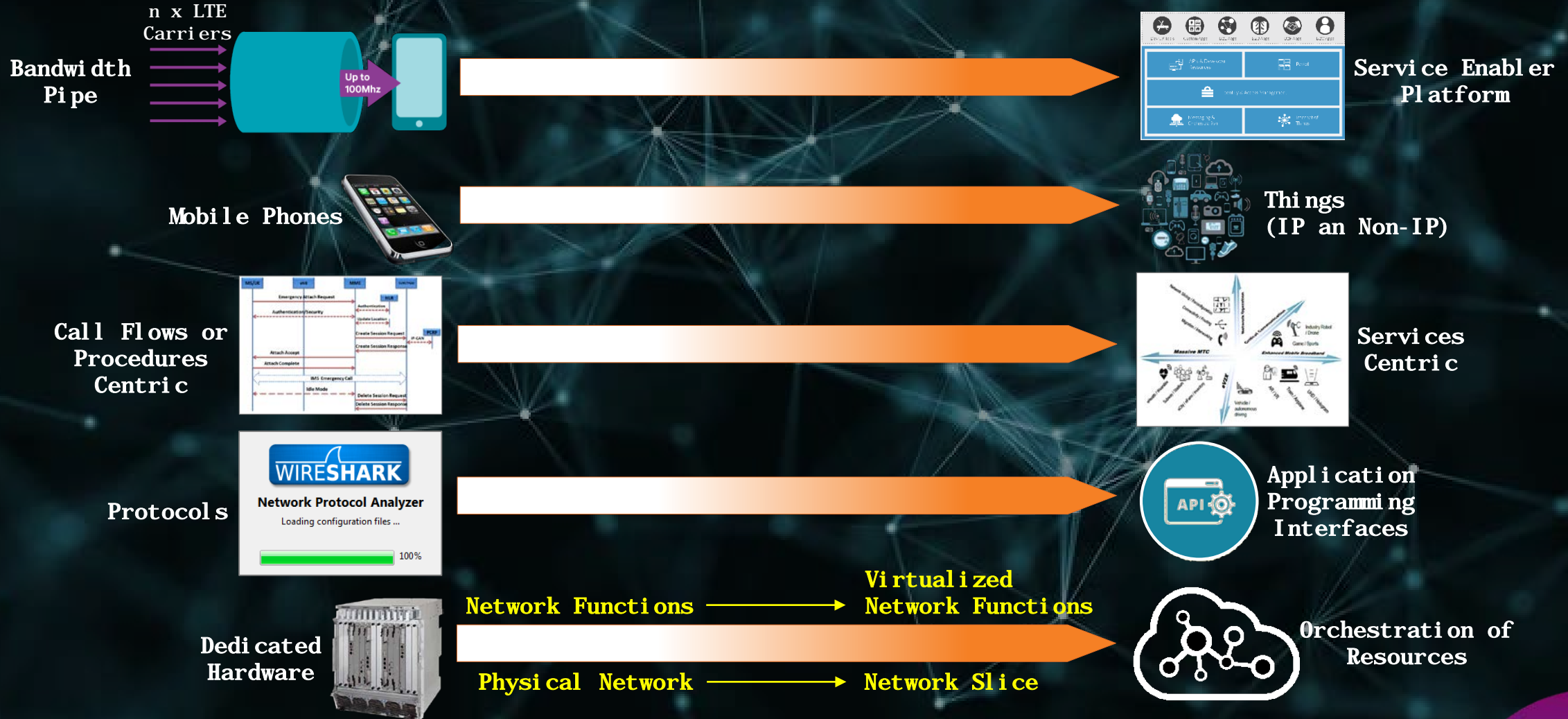
**Tower Lobby ca**



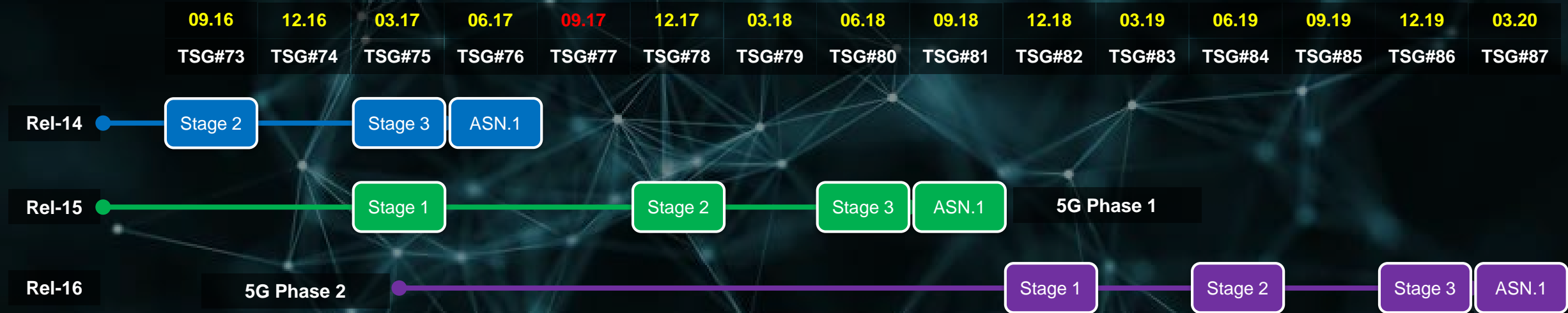
**Unauthorized Entry**



# Significant Network Evolution is Expected in Future Networks Transformation Towards a Software & Service Centric Architecture



# Future Networks: 3GPP Standardization Status Overview and the Key Aspects of 5G Networks



- Rel-14 freezing (completion of ALL items) at TSG#76
  - Some aspects continue (e.g. testing, legal intercept) but expected to conclude by 12.17
- Rel-15
  - Stage 1 freeze at TSG#76
  - Underway: Stage 2 5G Work on architecture, security, charging, management in SA, studies on 5G aspects of protocols, end-to-end aspects in CT, studies on RAN aspects





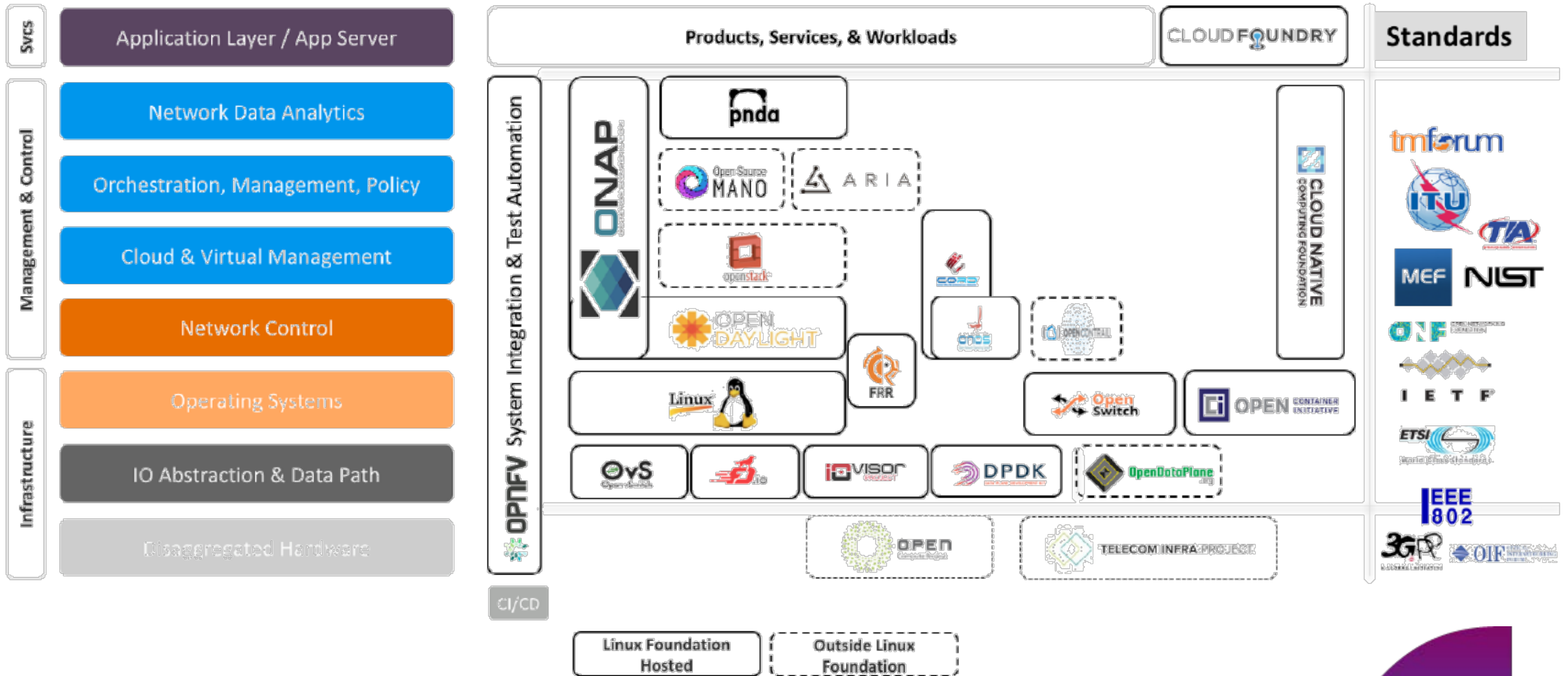
# Future Networks: Standards vs Open Sources (Part One)

Key Standards Development Organizations and Forums Chartering the Path for 5G and Future Networks



# Future Networks: Standards vs Open Sources (Part Two)

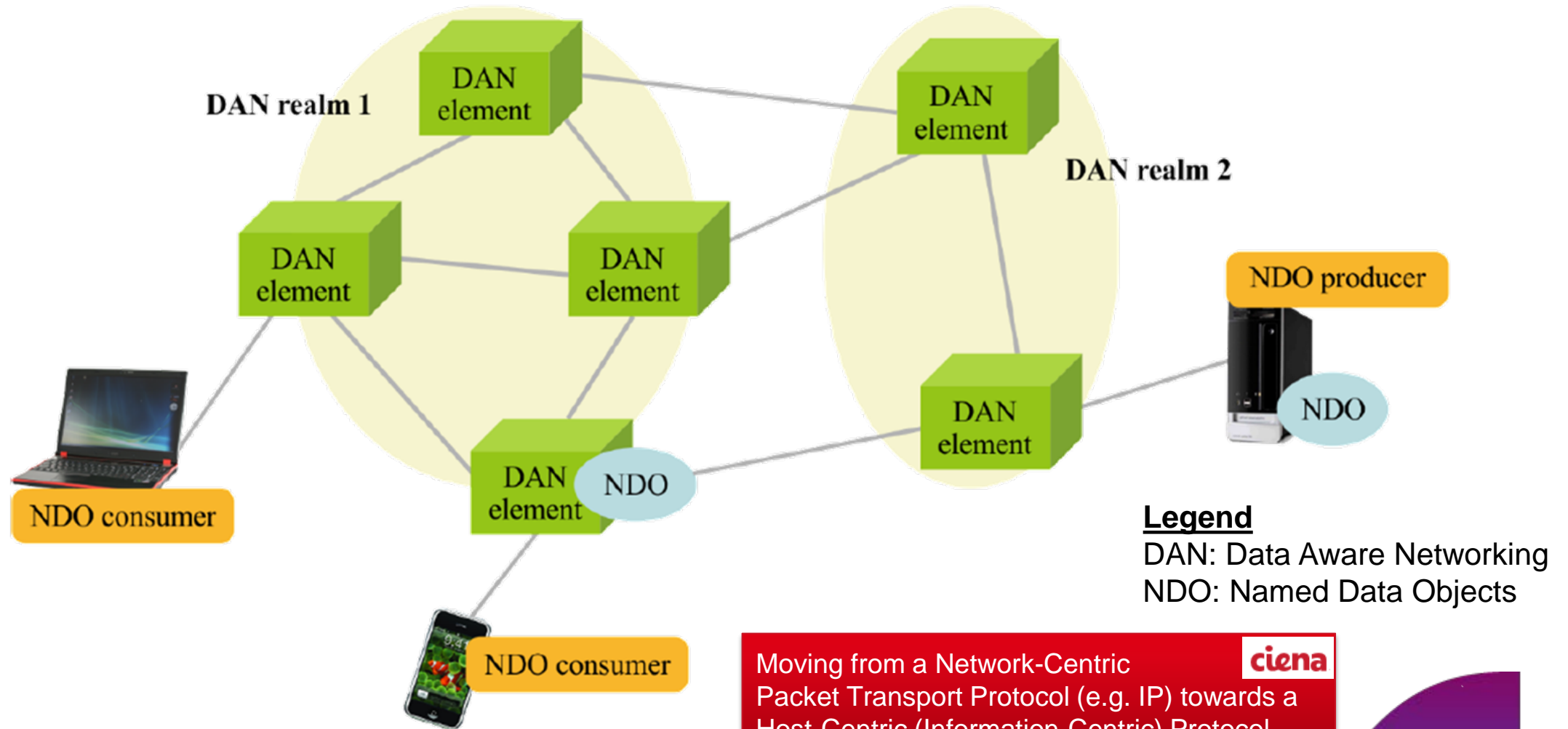
## Linux Foundation Unified Open Networking & Orchestration Architecture





# Future Networks: What Next Generation Protocol Really Means

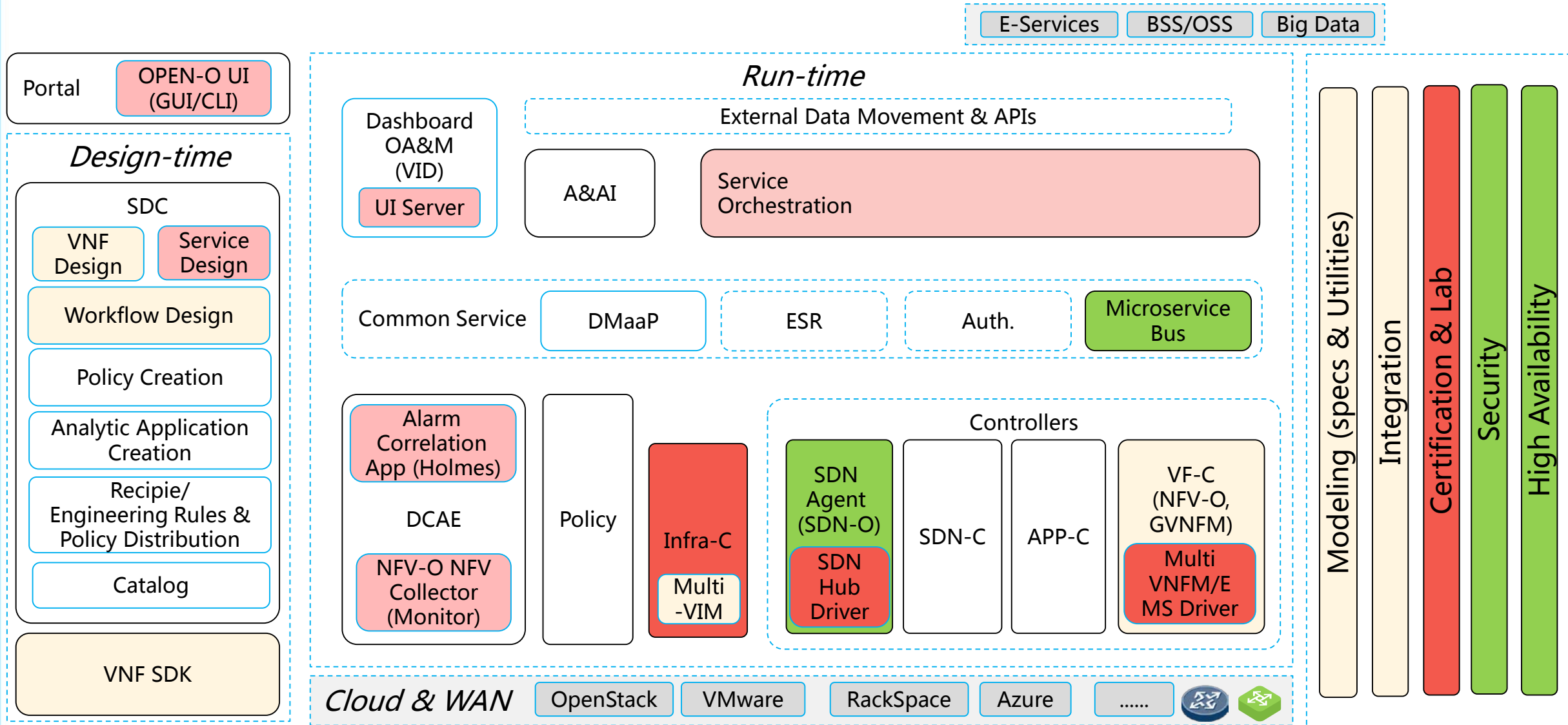
## ITU-T SG-13 Y.3071 Data Aware Networking (Information Centric Networking)



Moving from a Network-Centric Packet Transport Protocol (e.g. IP) towards a Host-Centric (Information-Centric) Protocol

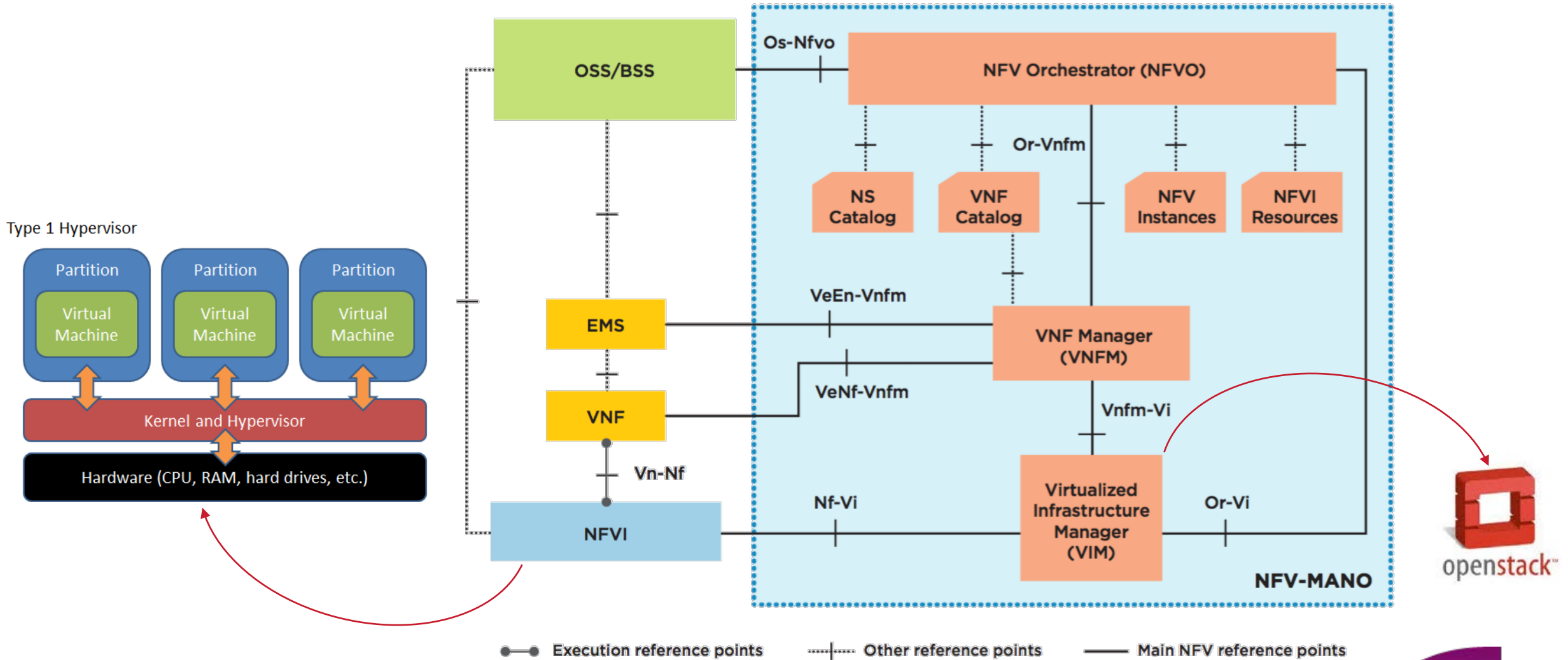


# Future Networks: ONAP Architecture





# Future Networks: Realization of ETSI NFV (Network Function Virtualization) & MANO (Management and Network Orchestration) Architecture



A graphical depiction of the NFV architecture, with the MANO components on the right side in blue.

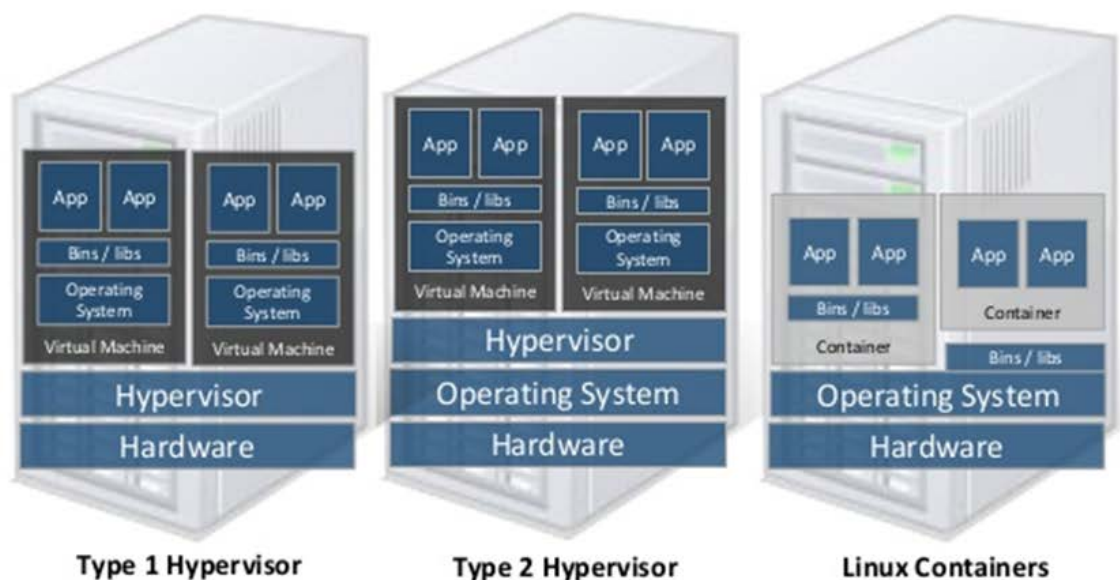
# Realization of Network Function Virtualization (NFV)

## Hypervisor Overview: Type of Hypervisors and Commercial Hypervisor Options

### Hypervisors vs. Linux Containers

Containers share the OS kernel of the host and thus are lightweight. However, each container must have the same OS kernel.

Containers are isolated, but share OS and, where appropriate, libs / bins.



Source: IBM

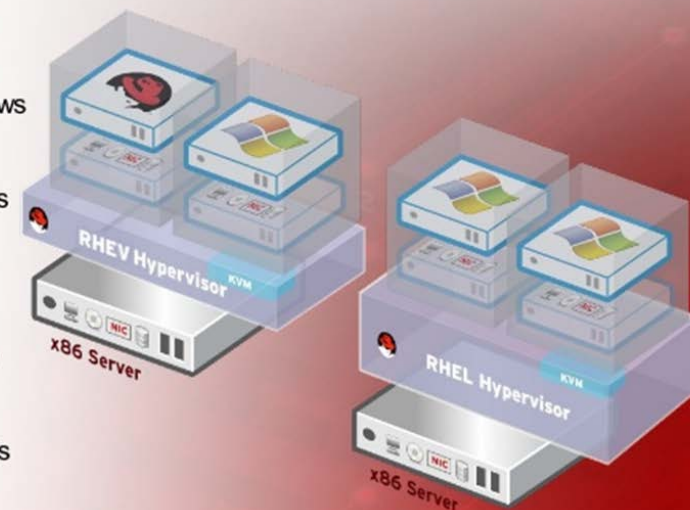
### TWO PACKAGING MODELS FOR THE HYPERVISOR

#### RHEV-HYPERVERSOR:

- Less than 100 MB
- Economically ideal for Windows guests, or mixed workloads (RHEL + Windows).
- Pre-configured, no Linux skills needed.

#### RHEL AS A HYPERVISOR:

- Flexible
- Security hardened, corporate standard RHEL image as a virtualization host.
- Add monitoring agents, scripts etc. Leverage existing RHEL infrastructure.
- Economically ideal for RHEL guests.
- Hybrid mode capable

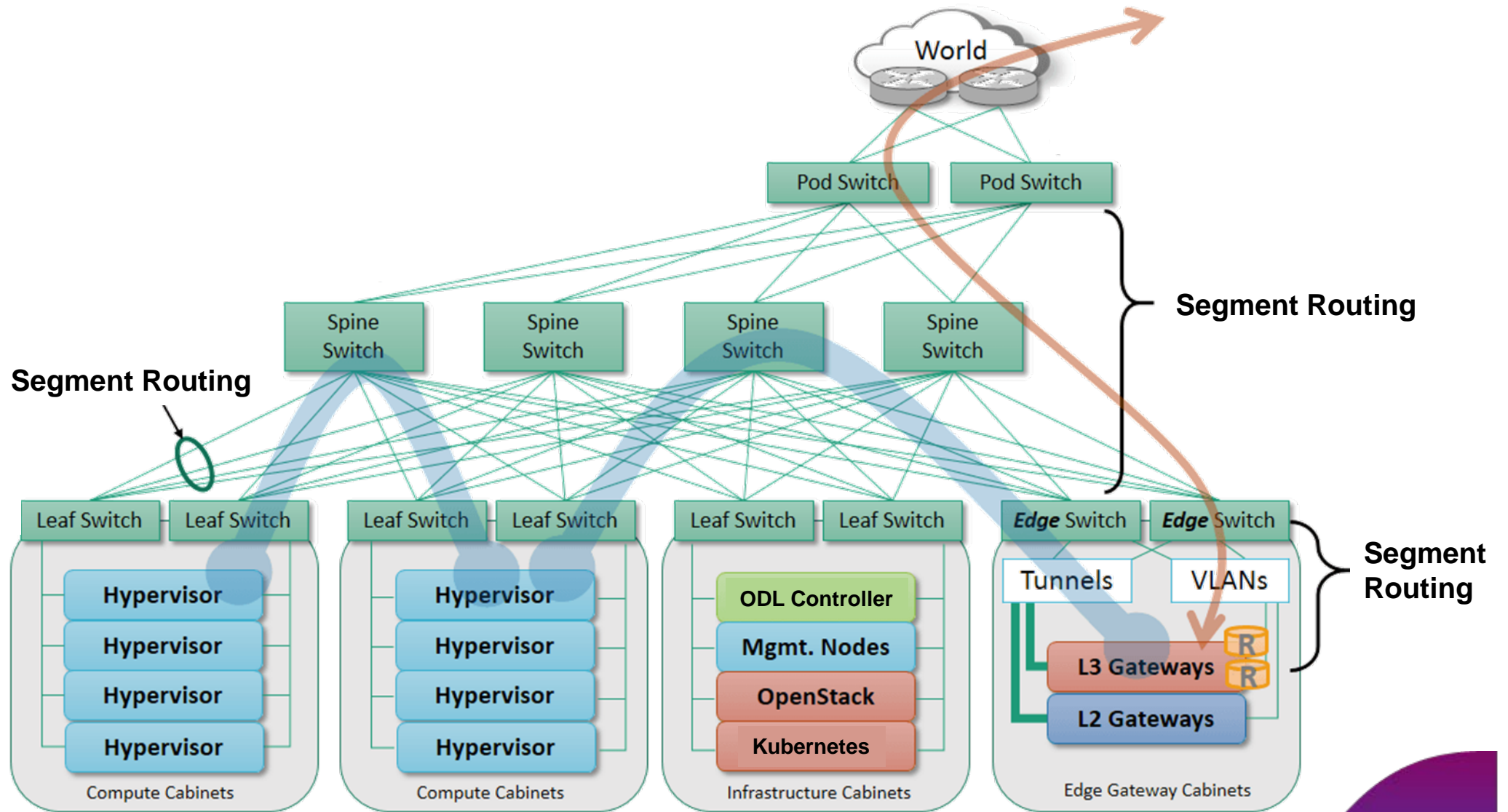


RED HAT ENTERPRISE VIRTUALIZATION | RED HAT INC.



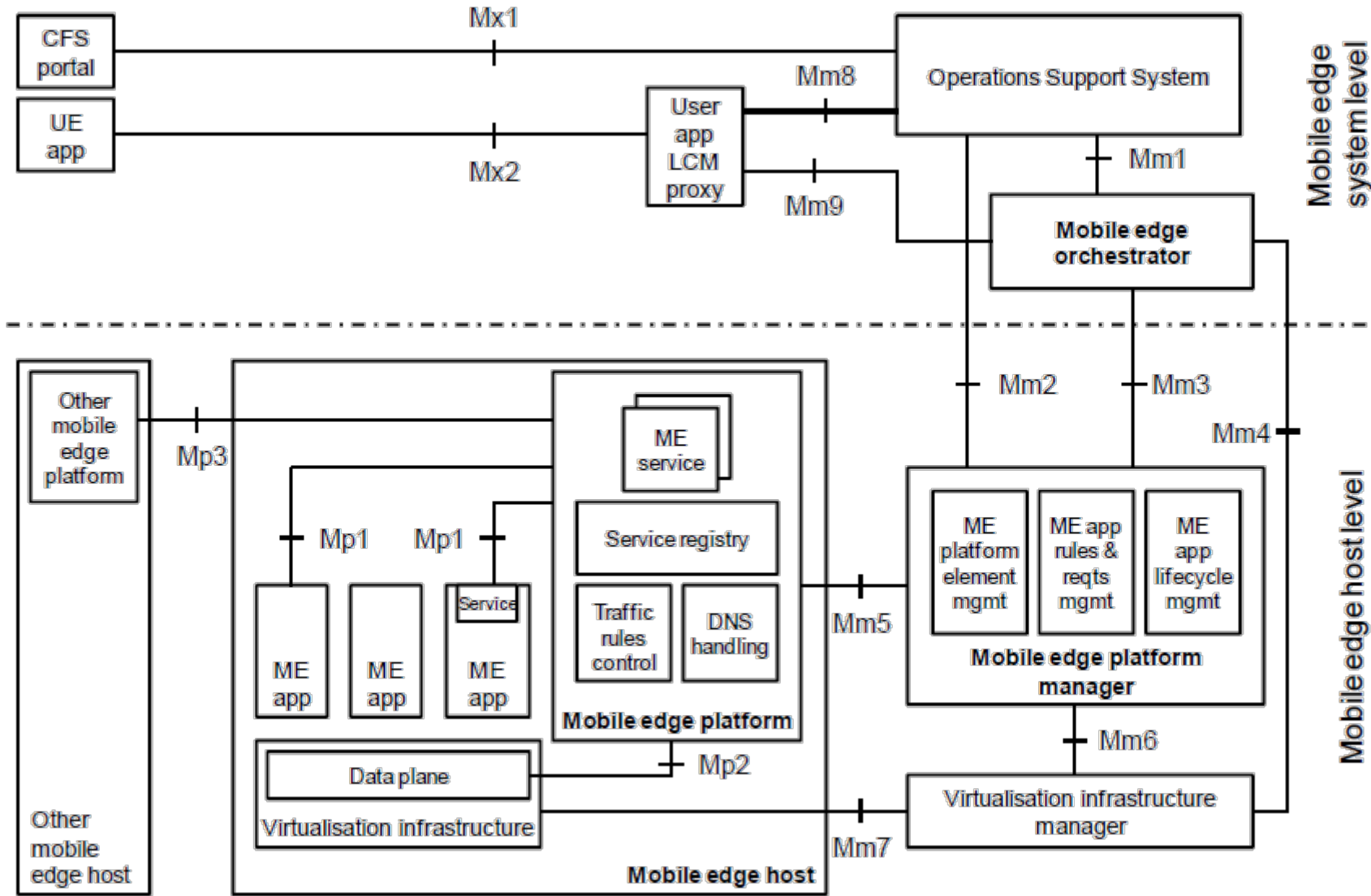
# Realization of Network Function Virtualization (NFV)

## Data Center Leaf/Spine Fabric for Cloud/Virtualization Deployments



# Future Networks: Realization of ETSI Multi-Access Edge Compute (MEC) Architecture

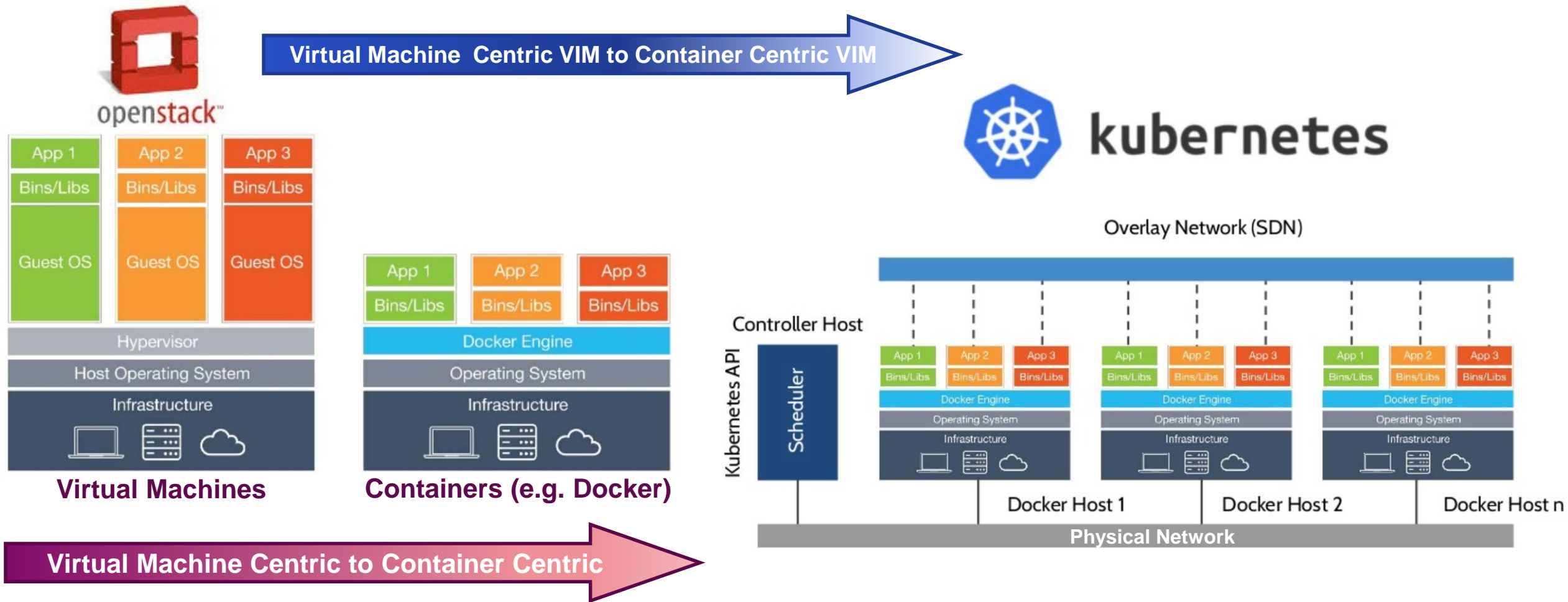
## Real Time Payloads Processing • Network Data Analytics & Continuous Control





# Realization of Network Function Virtualization (NFV)

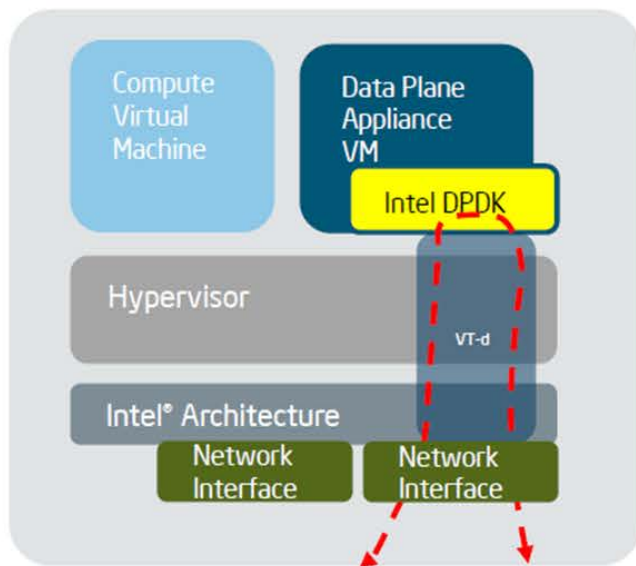
## Virtualization Environments Evolution Trends



# Realization of Network Function Virtualization (NFV)

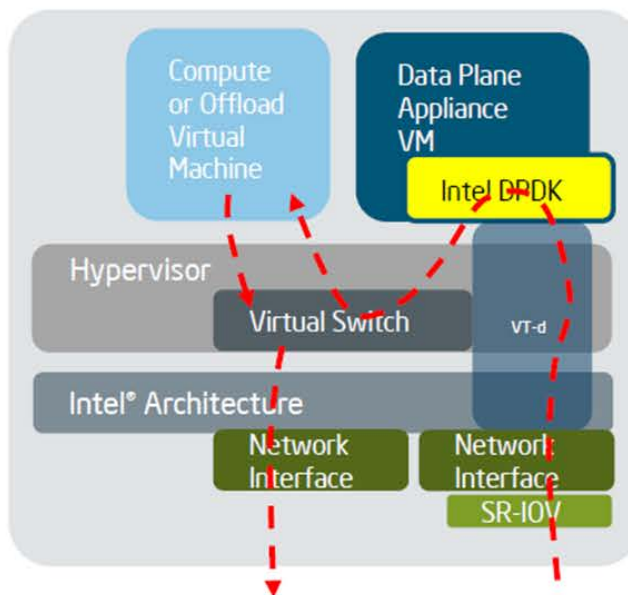
## Data Plane Virtualization Trends

Virtualization for Directed I/O  
Packets are routed to Virtual Machine using DirectPath I/O.  
Limited flexibility but native performance



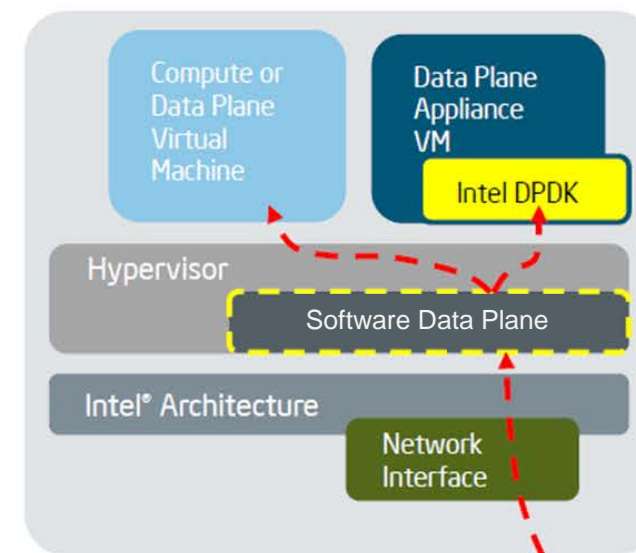
Standalone appliance integration,  
Firewall, WAN acceleration, Traffic Shaping

Hybrid Switching Solution,  
combining vSwitch support with  
direct assignment of SR-IOV  
Virtual Function



Service Chaining, Unified Threat Management, Intrusion Detection / Prevention

Optimized Virtual Switching solution,  
combining flexibility with performance.  
Support for live migration and data plane performance.



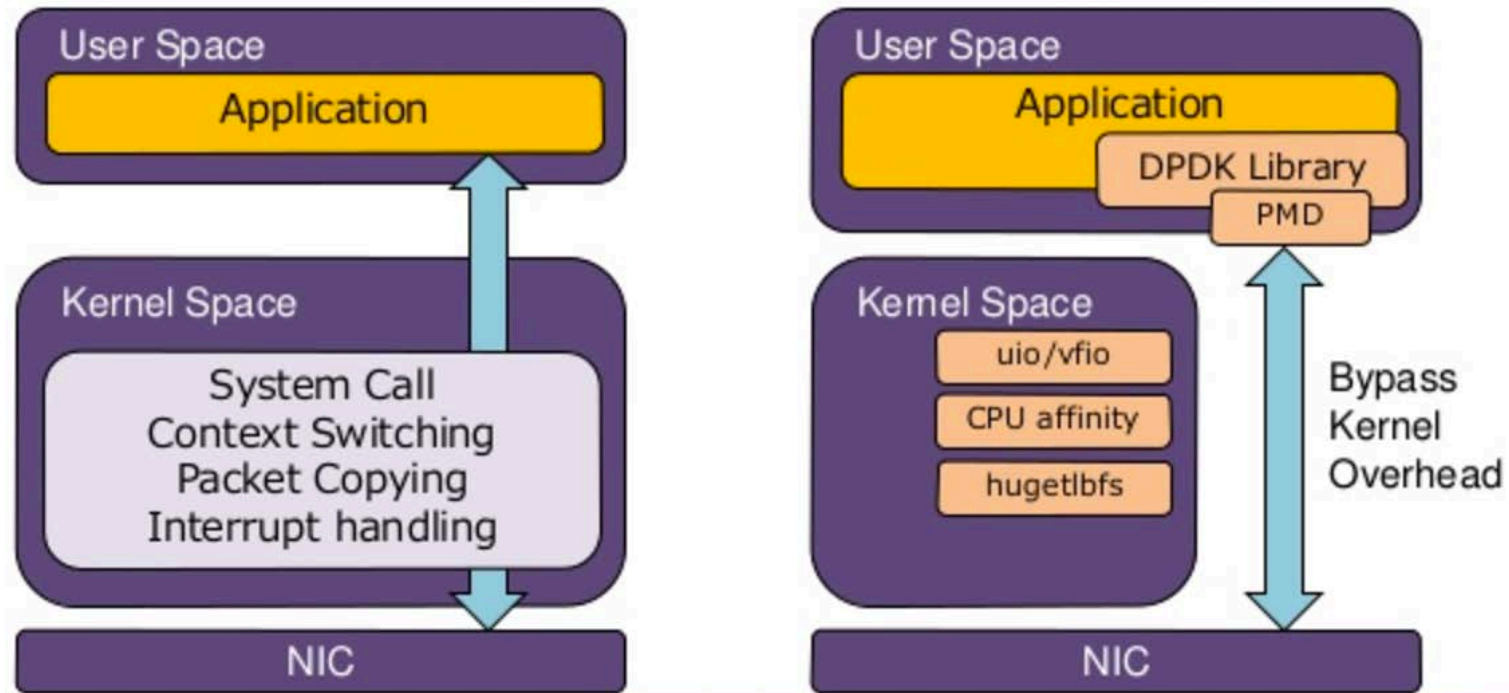
Increasing flexibility through high performance soft switching supporting both communications and compute workloads

The Rise of Software Data Plane Technologies in NFV Infrastructure



# Realization of Network Function Virtualization (NFV)

## Boosting Packet Processing Performance and Throughput with DPDK

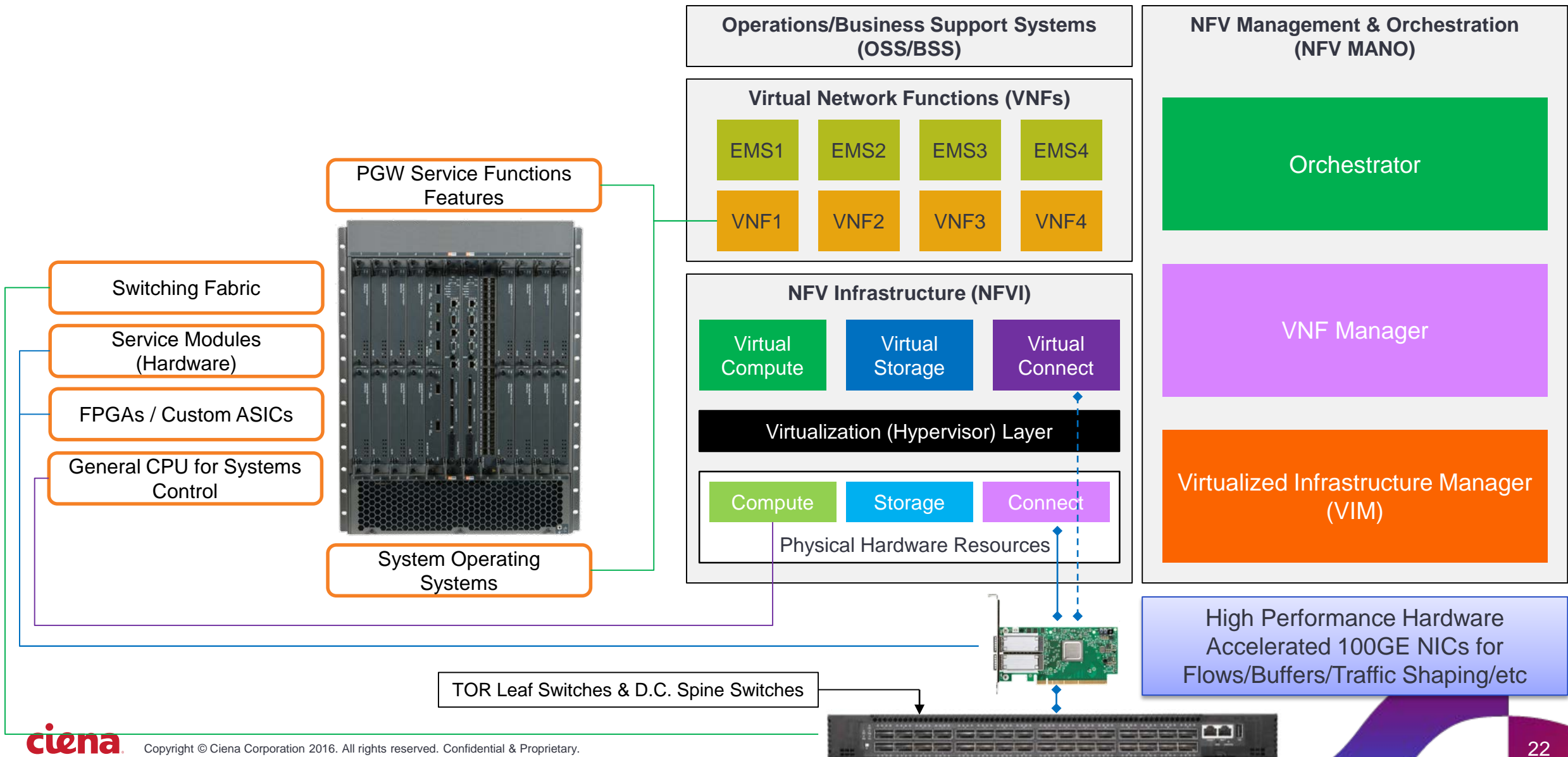


DPDK **is not** a Software Data Plane either. It's a Driver for Kernel Bypass in NFV Virtualization Environments



# Why Does All This Matter: Virtualization of a Mobile Packet Gateway

## Disaggregation of a PDN Gateway PNF (Physical Network Function)

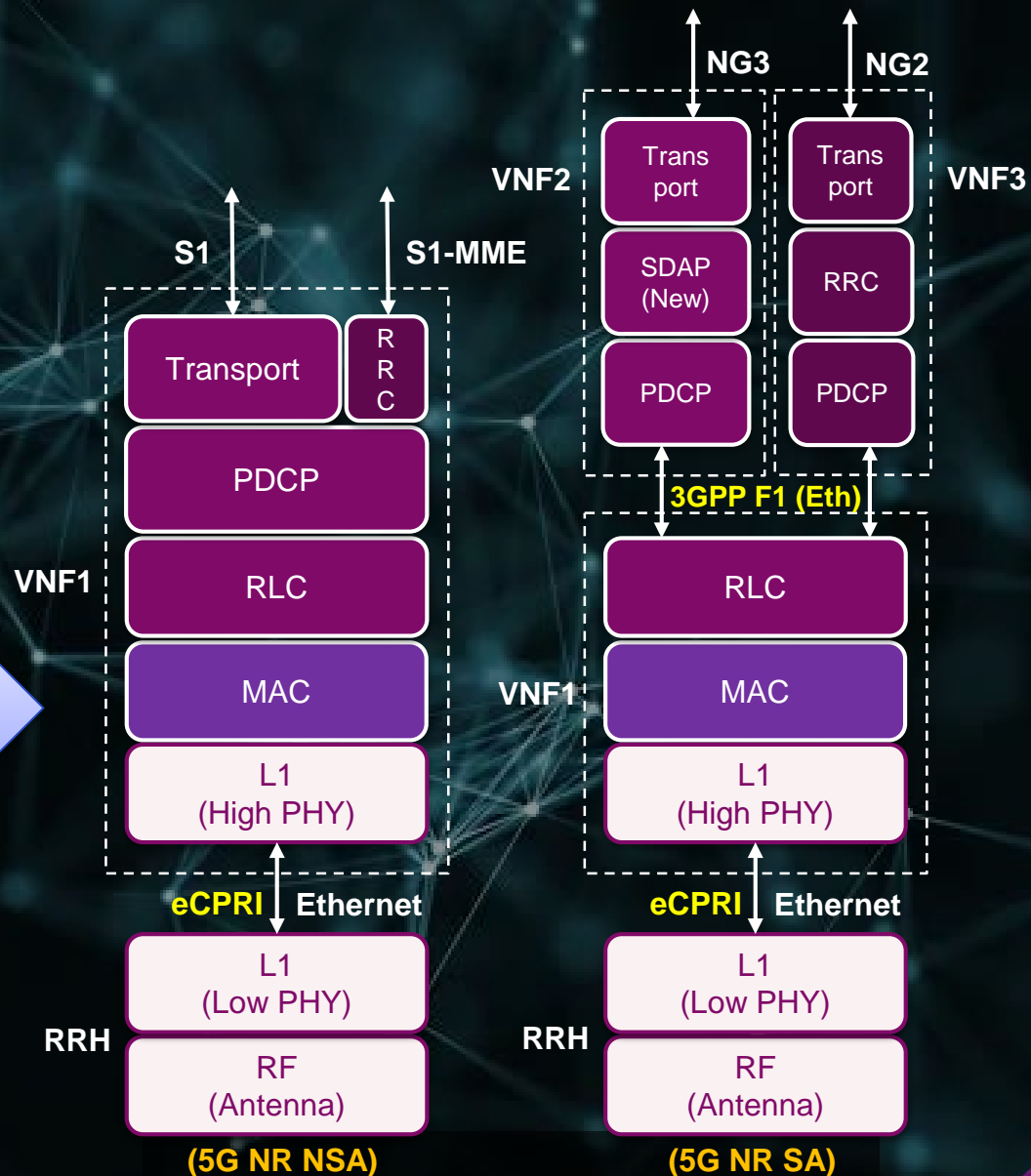




# Why Does All This Matter: Realization of RAN Virtualization in 5G Radio



**Traditional Base Station  
(Proprietary Form Factor  
& Closed Software)**



**(5G NR NSA)**

**(5G NR SA)**

**C-RAN with RAN Virtualization, Flexible  
Function Splits and CP/UP Separation**

## Key Takeaways for Today

- **Network Functions Virtualization will re-shape the telecommunications industry moving forward**
- **Multi-Access Edge Compute will be adopted in 5G access network for handling real-time traffic payloads**
- **Real-time network data analytics, on top of big data analytics, will be required in 5G networks**
- **Evolution from Network-Centric to Information-Centric networking technologies will happen in phases for Future Networks**





Thank You

Questions:

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