中華電信
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SDN/NFV(軟體定義網路/網路功能虛擬化)之發展現況與應用實例

朱煜煌
中華電信研究院
108.08.05

Refresh your life

大綱

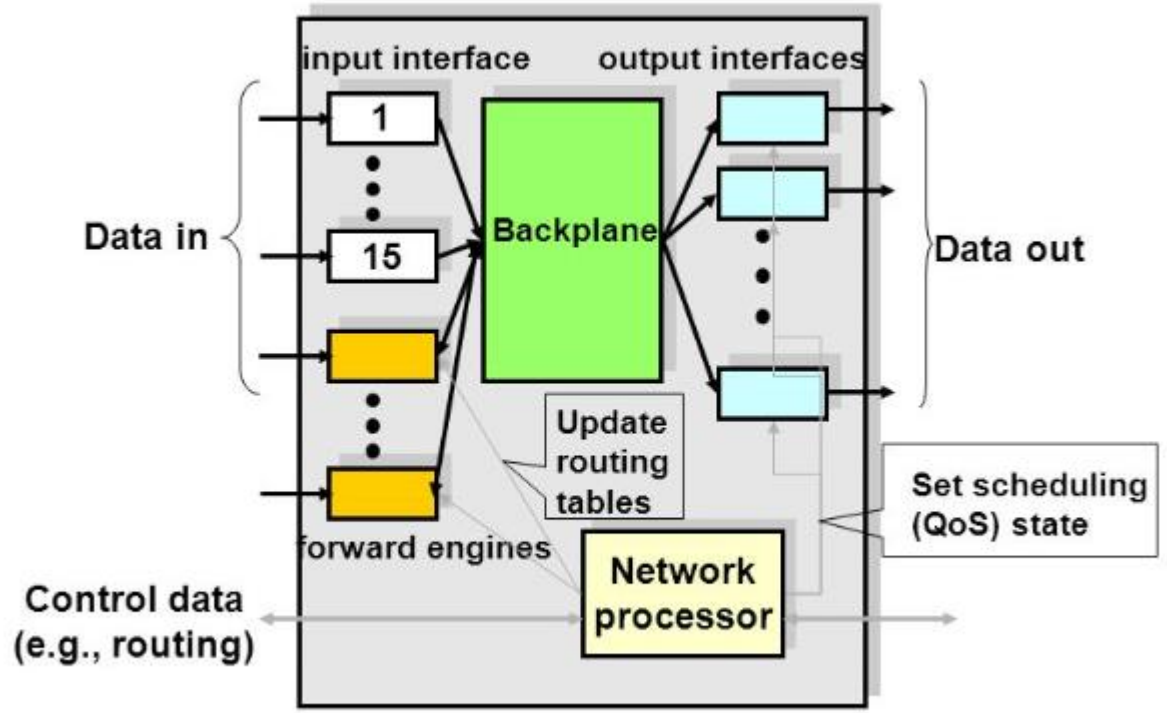
- SDN/P4 Protocol/NFV概念介紹
- SDN/NFV發展趨勢
- 5G網路及應用
- SDN/NFV落實案例分享

SDN 軟體定義網路
NFV 網路功能虛擬化

Router Architecture (1/2)

Two key router functions:

- run routing algorithms/protocol (RIP, OSPF, BGP)
- *switching* datagrams from incoming to outgoing link



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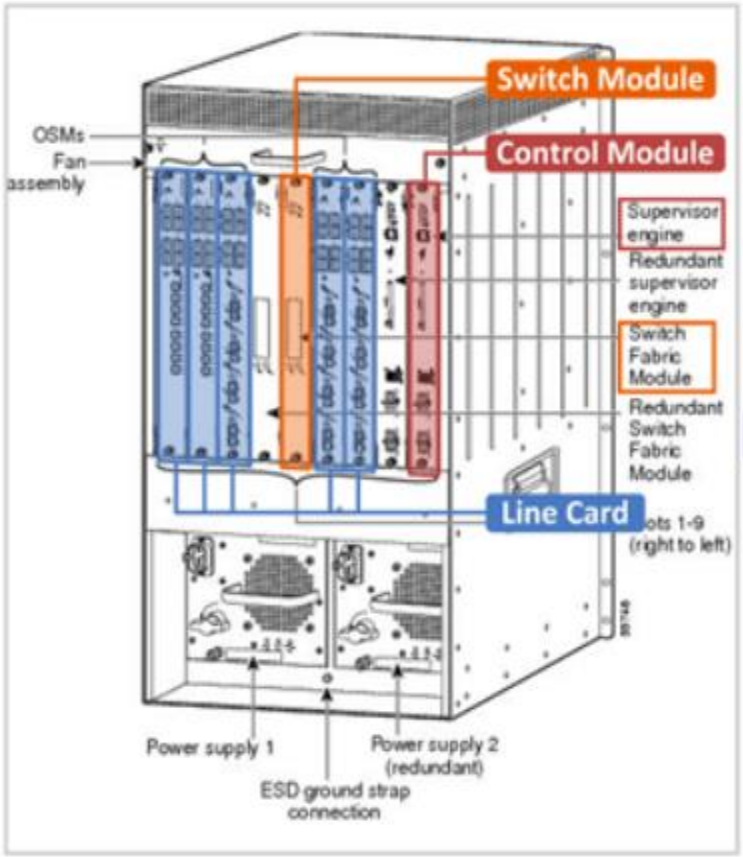
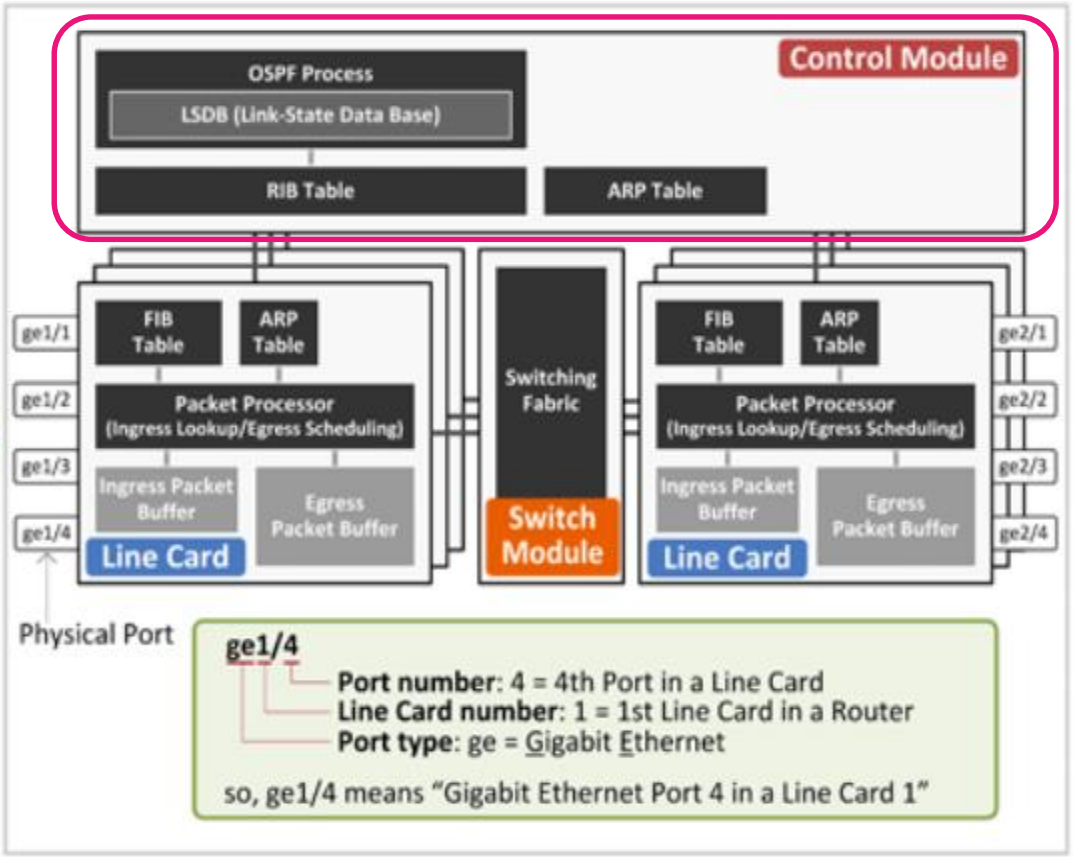
Router Architecture (2/2)



Cisco 7600 Router



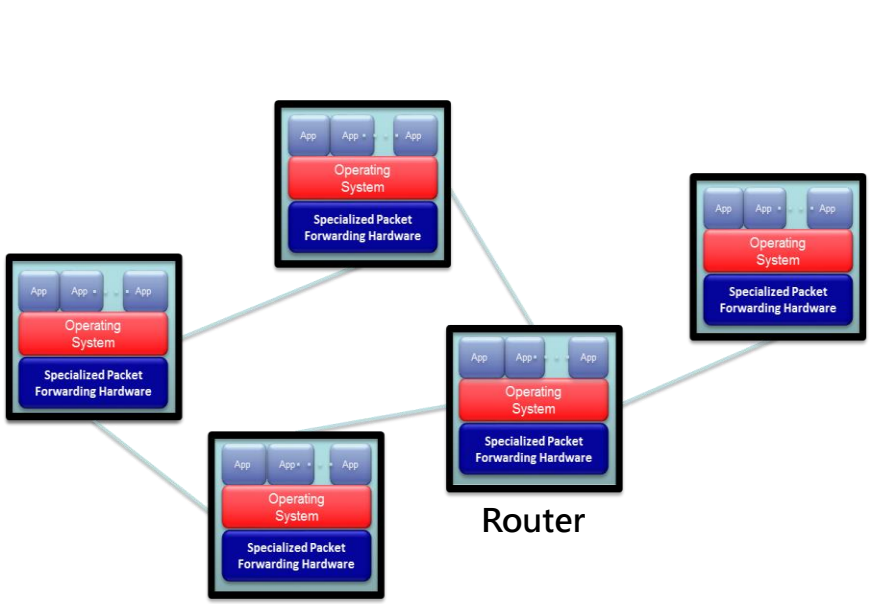
General Router Architecture

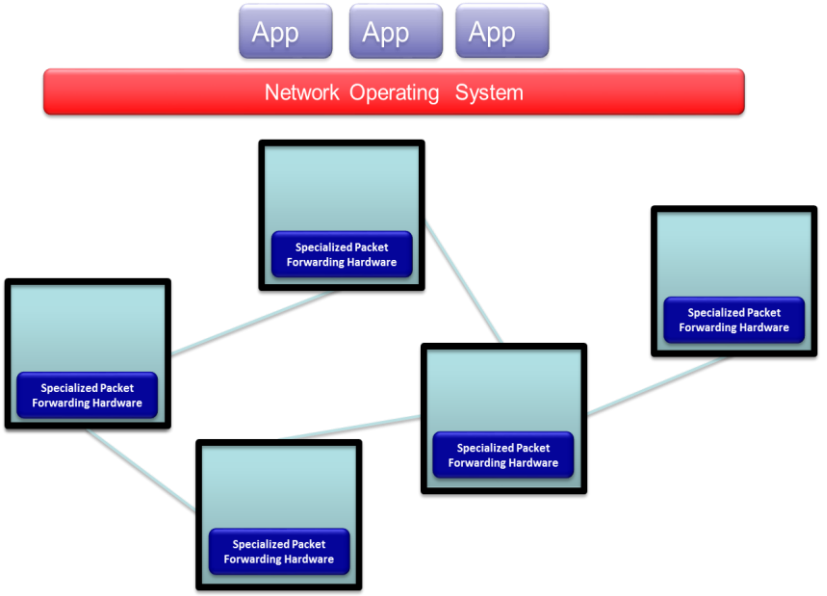
https://www.netmanias.com/en/post/blog/6338/ip-routing-network-protocol-switching/switching-and-routing-part-1-router-architecture

SDN: Software Defined Network

現有網路
- 網路設備獨立運作
- OSPF, BGP, ..
- 網路設備(Router)複雜,功能多
- 分散式設定

SDN網路
- 網路設備簡單,功能少
- 網路設備無法獨立運作，需有控制器下達指令
- 可集中管理

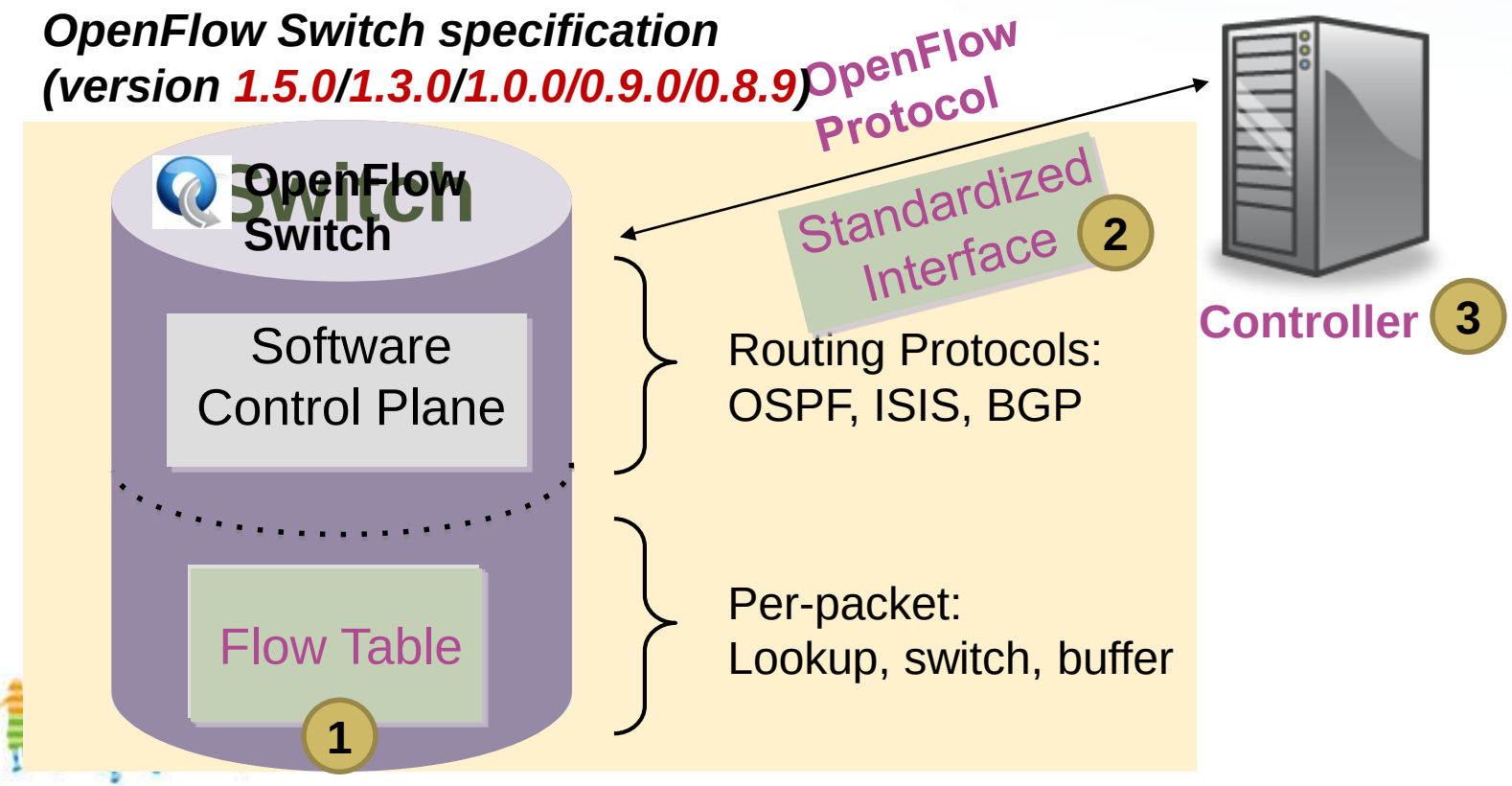




What is OpenFlow

OpenFlow來實現SDN

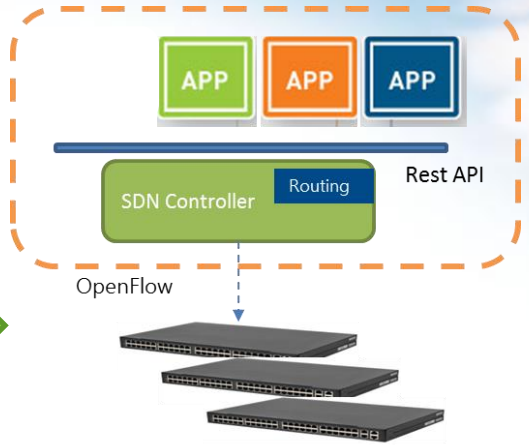
- OpenFlow is based on an Ethernet switch or WiFi access point, with an (1) internal flow-table and a (2) standardized interface to add and remove flow entries via an (3)OpenFlow Controller



SDN技術發展

ONF開源方案

SDN
方案一

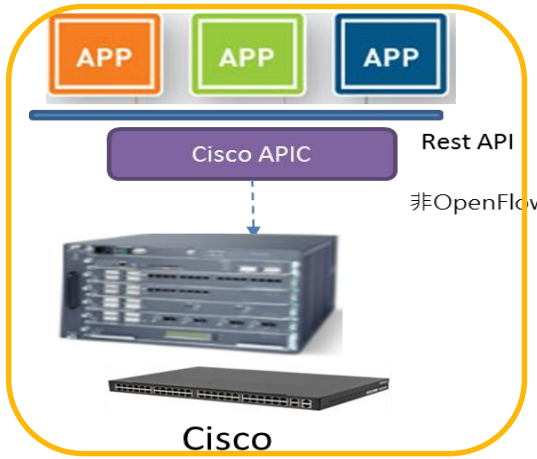


■2011年 ONF提出SDN架構

- OpenFlow 交換器
- OpenFlow控制器
- 網路APP

Cisco

SDN
方案二



■ 2013年 IETF提出SDN另外實現概念

- 既有的網路設備(路由器、交換器)、私有控制器
- OpenFlow並非唯一標準
- 網路APP

ONF: Open Network Foundation
IETF: Internet Engineering Task Force

廠商的解決方案

ONF SDN & IETF SDN比較

	【ONF SDN】	【IETF SDN】
SDN精神	• 轉發與控制完全解構/分離 • Revolution	• 設備仍可保有部分控制權 • Evolution
南向網路介面標準	• Define the New protocol • 統一採OpenFlow協定標準	• 延伸既有協定：Reuse, reuse, reuse • 多元 (Netconf, PCEP…)
創新面	• 顛覆式創新，運營商具高度研發自主權/話語權，扭轉過往廠商主導的生態 • 助益運營商轉型為solution provider	• Vendor方案為主，相對封閉，較不利於運營商創新切入
成本面	• 結合商用/白牌/Bare Metal設備(可搭配開源軟體)，利於降低建置成本	• 傳統大廠商用產品，成本降低不易
維運面	• 維運單位員工需要學習新的IT維運能力，接受度低，維運意願低 • 維運工作易轉嫁至研發單位，導致研發單位負荷沉重，陷入泥淖無法脫身	• 基於既有IP與MPLS技術予以延伸，員工接受度高 (接地氣)
挑戰性	• 解耦+整合，技術/非技術之挑戰相對高	• 相對容易導入

Open Networking Foundation

- A non-profit industry consortium
  - Founded: March 2011
  - More than 70 members
    - Telecom operators, network providers, service providers
    - Equipment vendors, networking and virtualization software suppliers, and chip technology providers

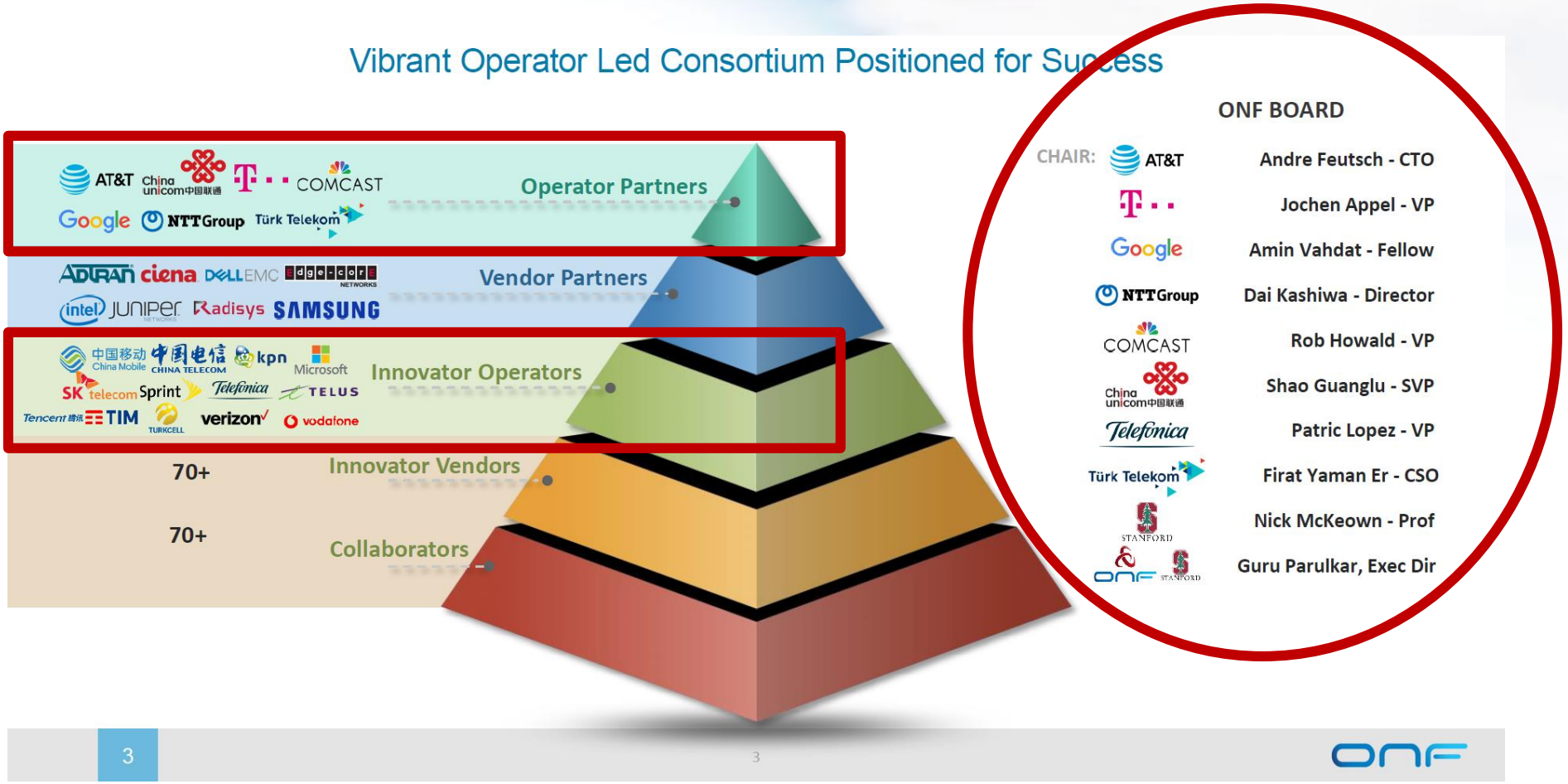
- **Vision: Make Software-Defined Networking the new norm for networks**
  - ONF wants to transform networking industry to software industry through SDN concept

- **Mission: Commercialize and promote SDN and its underlying technologies for their user benefits**
  - ONF strives to create the most relevant SDN standards

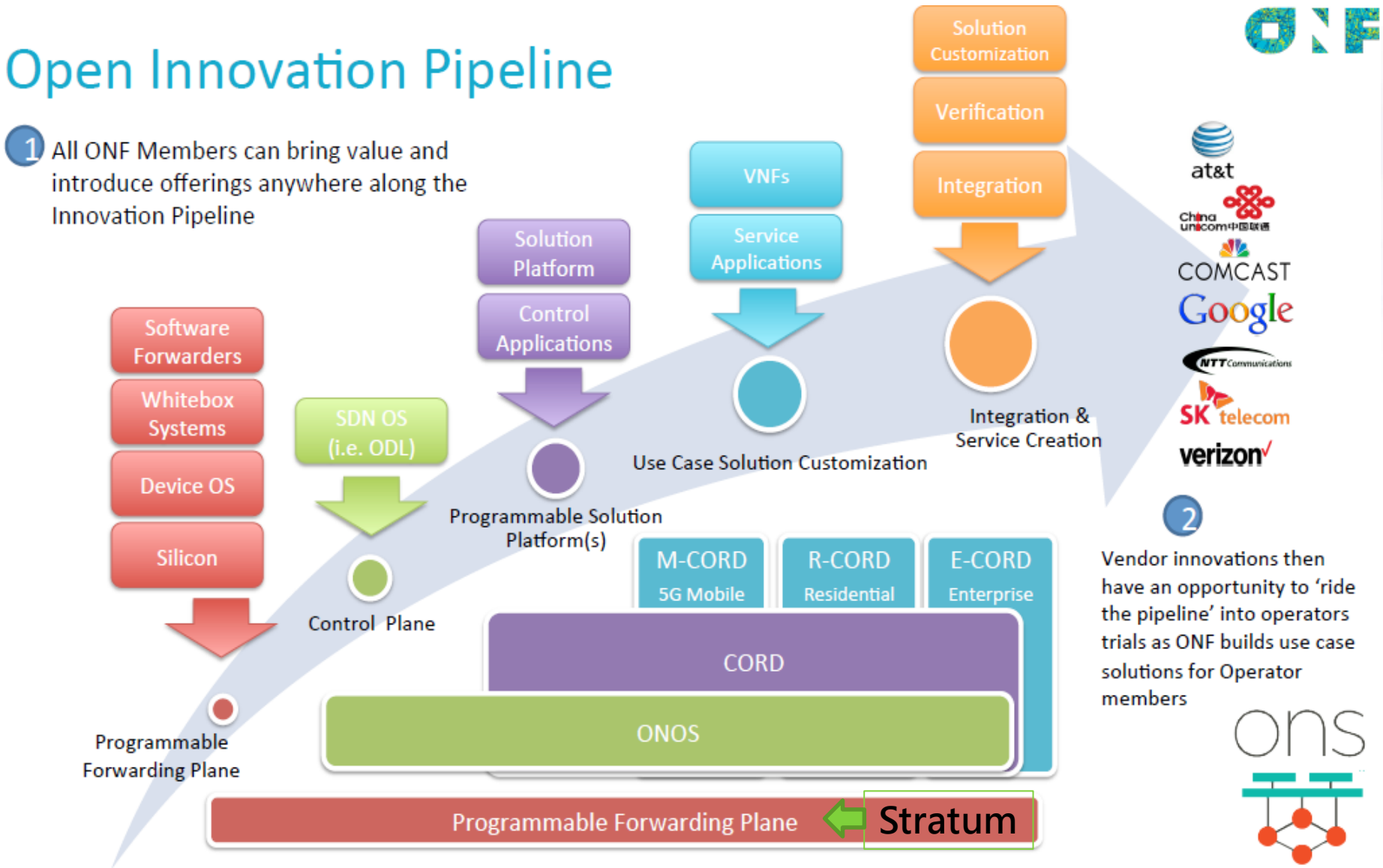
SDN is a dynamic and flexible network architecture that protects existing investments while future-proofing the network.
With SDN, today's static network can evolve into an extensible service delivery platform capable of responding rapidly to changing business, end-user, and market needs.
[https://www.opennetworking.org/images/stories/downloads/white-papers/wp-sdn-newnorm.pdf]

ONF – 由Operators領導

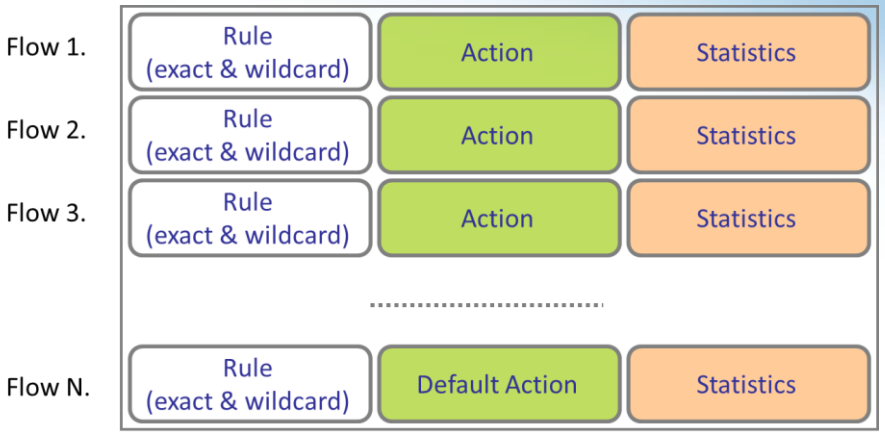
OPERATOR-LED NOT-FOR-PROFIT CONSORTIUM



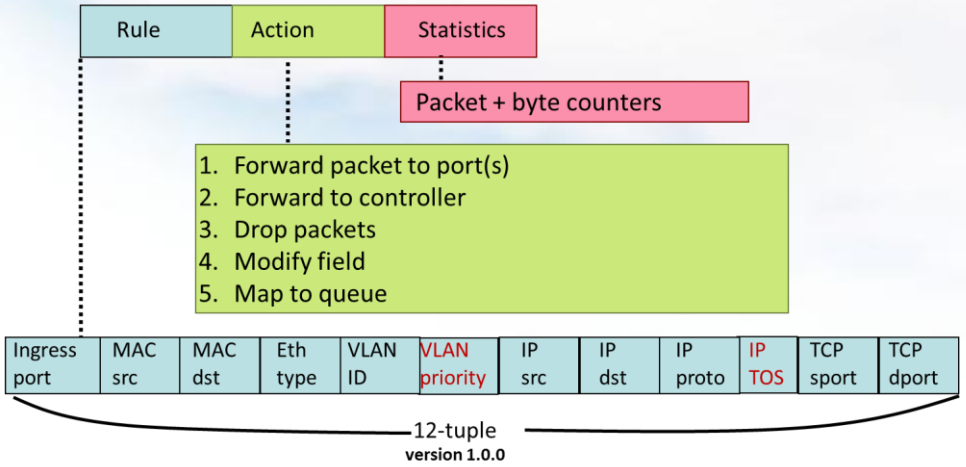
ONF實踐架構


Open Innovation Pipeline
1 All ONF Members can bring value and introduce offerings anywhere along the Innovation Pipeline
Solution Customization
Verification
Integration
VNFs
Service Applications
Solution Platform
Control Applications
Software Forwarders
Whitebox Systems
Device OS
Silicon
SDN OS (i.e. ODL)
Integration & Service Creation
Use Case Solution Customization
Programmable Solution Platform(s)
Control Plane
M-CORD 5G Mobile
R-CORD Residential
E-CORD Enterprise
CORD
ONOS
Programmable Forwarding Plane
Programmable Forwarding Plane
Stratum
at&t
China unicom中国联通
COMCAST
Google
NTT Communications
SK telecom
verizon
2
Vendor innovations then have an opportunity to 'ride the pipeline' into operators trials as ONF builds use case solutions for Operator members
ons

Openflow 1.0 Flow Table



- Rules to match against packets
- Actions to apply to matching packets
- Statistics to update for matching packet



Ethernet Switching

Intress port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Proto	TCP sport	TCP dport	Action
*	*	00:23:7d: bc:5a:c5	*	*	*	*	*	*	*	port6

Firewall

Intress port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Proto	TCP sport	TCP dport	Action
*	*	*	IP	*	*	*	TCP	*	80	drop

IP Multicasting (也可以Unicasting)

Intress port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Proto	TCP sport	TCP dport	Action
*	*	*	IP	*	*	10.1.*.*	*	*	*	port 6 port 7 port 8

Flow Entry數量: 是評估OpenFlow 交換器的重要因素

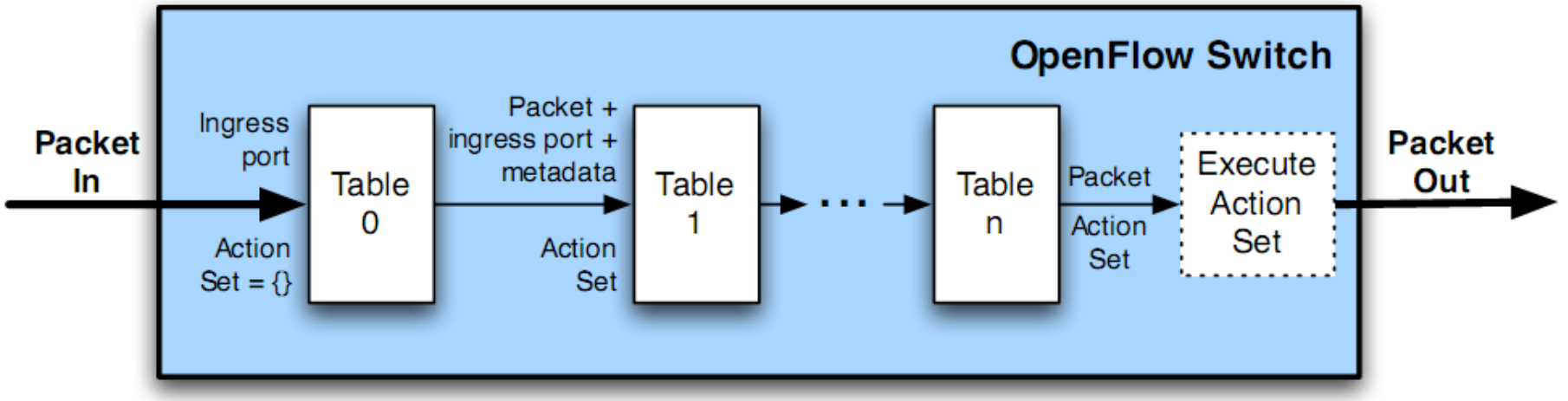
OpenFlow 版本

Version	Date	Header Fields
OF 1.0	Dec 2009	12 fields (Ethernet, TCP/IPv4)
OF 1.1	Feb 2011	15 fields (MPLS, inter-table metadata)
OF 1.2	Dec 2011	36 fields (ARP, ICMP, IPv6, etc.)
OF 1.3	Jun 2012	40 fields *LTS*（長期支持）
OF 1.4	Oct 2013	41 fields

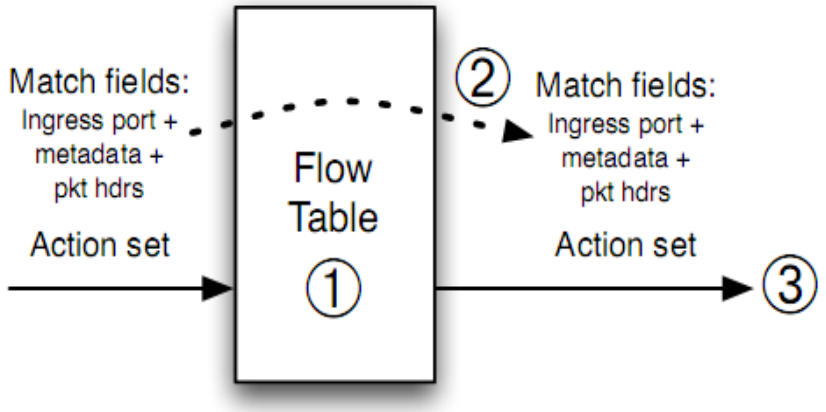
- 自OpenFlow1.0發布以來，其版本目前已經演進到1.5
- 標頭欄位(Header Fields)的個數：從1.0版的12個 ➔ 1.3版的40個 ➔ 1.5版的45個
- Header fields數目隨著新版本不斷增加

目前沒有支援OpenFlow的專屬芯片

OpenFlow spec 1.3



(a) Packets are matched against multiple tables in the pipeline



① Find highest-priority matching flow entry

② Apply instructions:
- i. Modify packet & update match fields (apply actions instruction)
- ii. Update action set (clear actions and/or write actions instructions)
- iii. Update metadata

③ Send match data and action set to next table

(b) Per-table packet processing

P4 Protocol -兩項創新

P4 技術探討：實踐 Data Plane 可編程

(Programming Protocol-Independent Packet Processors)

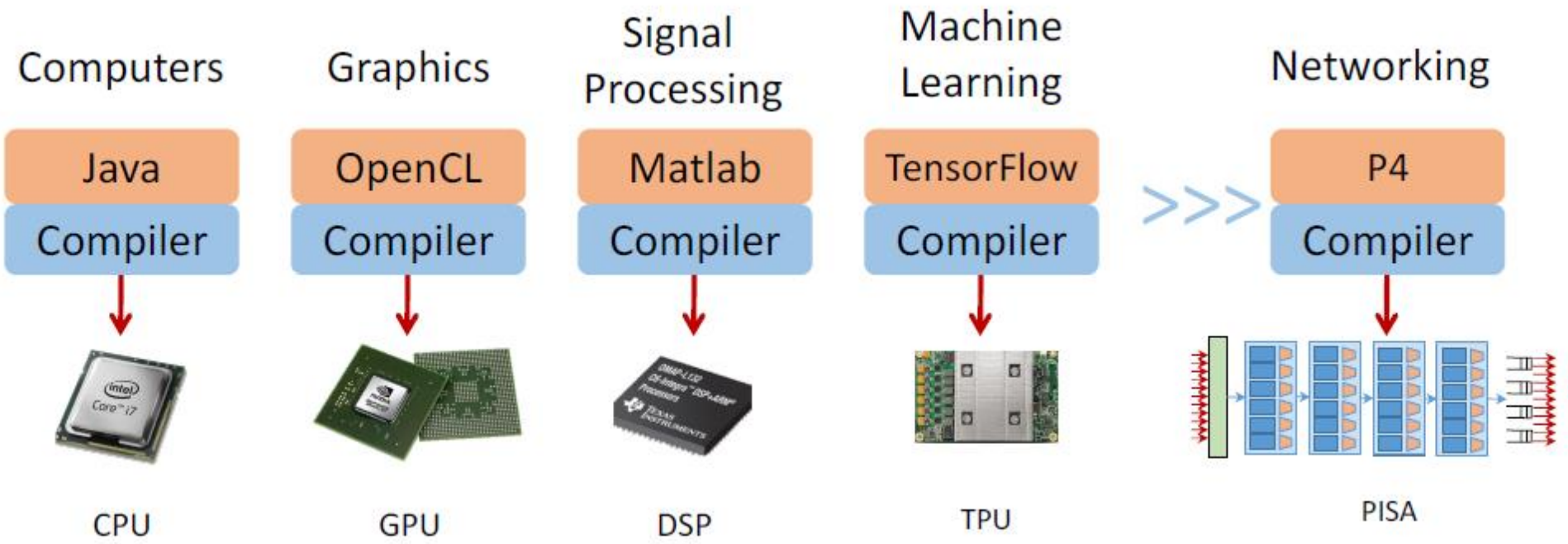
可自創協議

(例如Inband Network Telemetry (“INT”)封包)

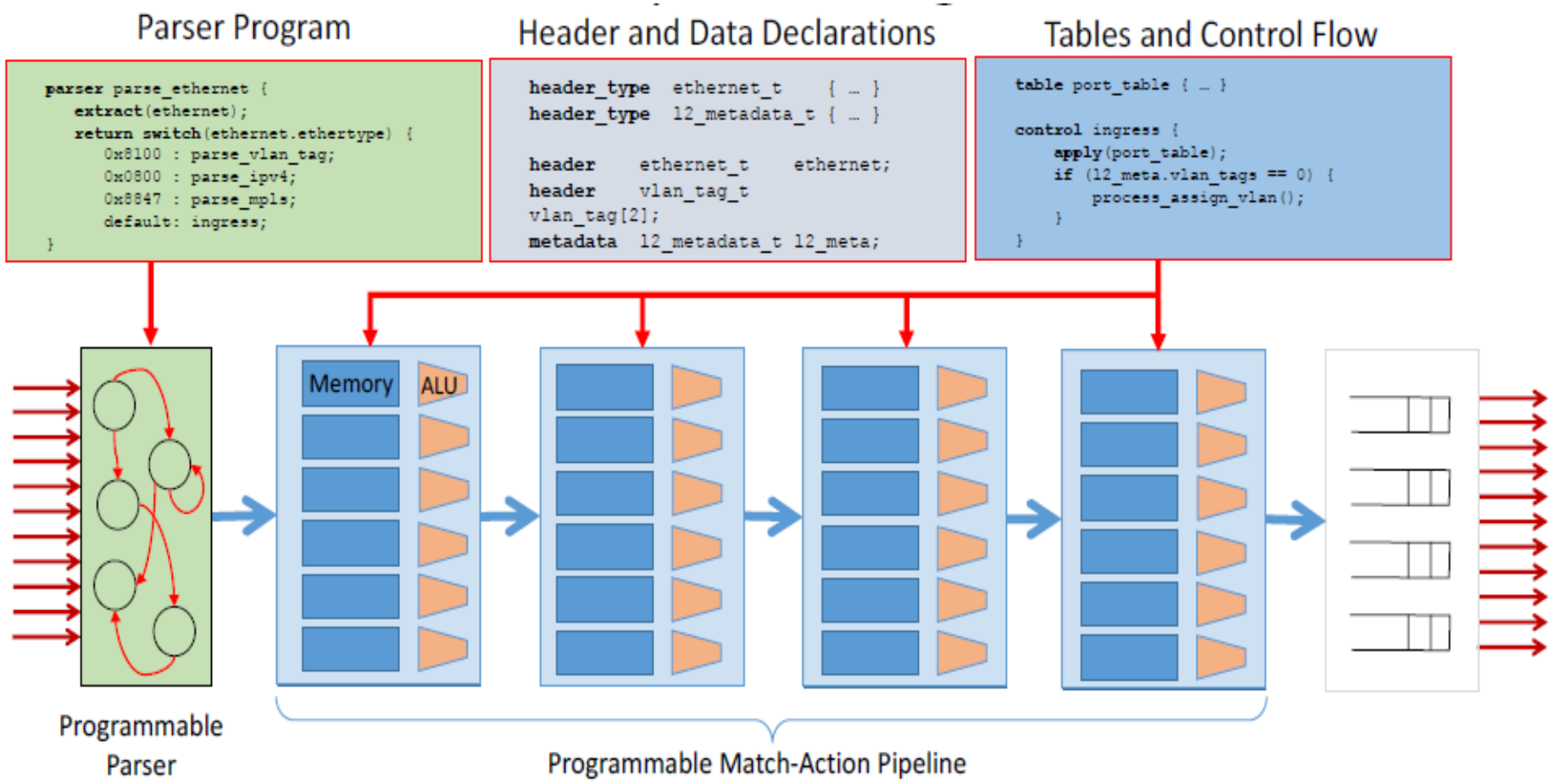
- **P4可編程交換晶片 (Tofino)** NEW
  - ✓ 新的芯片 (P4 客製, 專屬)
  - ✓ 採用PISA (Protocol-Independent Switch Architecture)架構

- **P4語言** NEW
  - ✓ The Data Plane Programming Language (聚焦於轉發平面/數據平面)
  - ✓ An open language for describing how switches should process packets (描述交換器該如何處理封包)

專屬Chipset

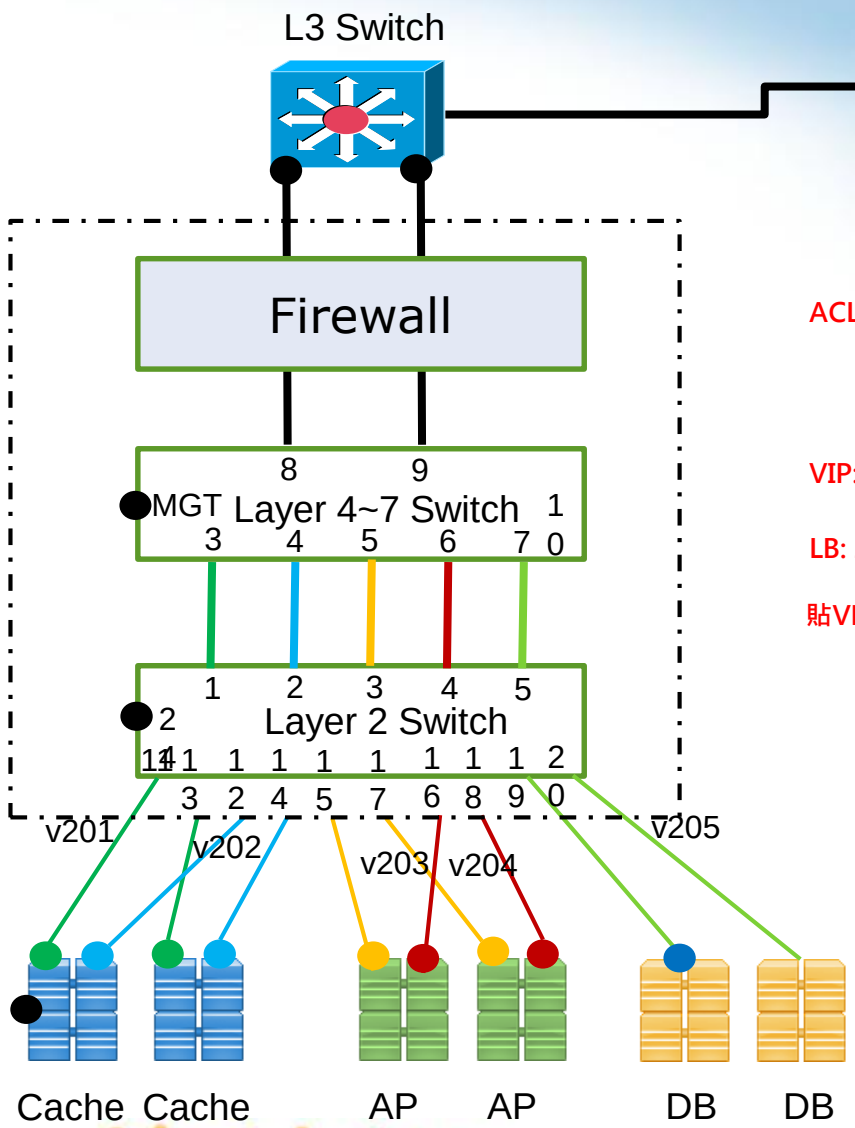

Computers
Java
Compiler
CPU
Graphics
OpenCL
Compiler
GPU
Signal Processing
Matlab
Compiler
DSP
Machine Learning
TensorFlow
Compiler
TPU
>>>
Networking
P4
Compiler
PISA

P4 Program Example



PISA: Protocol Independent Switch Architecture

MxD平台



ACL: Src IPv4比對

VIP: DST IPv4比對

LB: 2 port

貼VLAN ID

P4 和OpenFlow的差異

OpenFlow	P4
• OpenFlow 是假定 switch 有固定並已知的行為，且通常描述於switch ASIC晶片的數據表中 • OpenFlow 允許我們在 forwarding entries 增加或刪除約五十種不同的header種類 • Switch供應商可以使用Open Networking Foundation (ONF)中的Table Type Patterns (TTP)標準來告知control plane支援哪些headers • OpenFlow 並不是真正控制 switch 的行為，而是給了我們一個建立一套已知表格的方法	• 在 P4 中，OpenFlow 是眾多可能的程式之一，都是在描述 forwarding plane 怎麼運行 • P4 和OpenFlow都專注於在開放式forwarding plane • P4 是“bottom-up”模式。P4 能夠告訴 switch 該如何處理封包，而不是讓 switch 限制我們能夠做的事情 • P4 讓我們能定義 switch 能辨識怎樣的 header (或是“parse”)，如何根據每個 header 來 match，以及該根據每個header該採取怎樣的action

NFV: Network Functions Virtualization

2012.10.22
13家電信公司
共同發起成立

OBJECTIVES

This is a non-proprietary white paper authored by network operators.

The key objective for this white paper is to outline the benefits, enablers and challenges for Network Functions Virtualisation (as distinct from Cloud/SDN) and the rationale for encouraging an international collaboration to accelerate development and deployment of interoperable solutions based on high volume industry standard servers.

使用情境: Datacenters, Network Nodes and in the end user premises

Virtualising Network Functions優點

- Reduced equipment costs and reduced power consumption
- Increased speed of Time to Market
- Availability of network appliance multi-version and multi-tenancy
- Services can be rapidly scaled up/down as required.
- Enables a wide variety of eco-systems and encourages openness

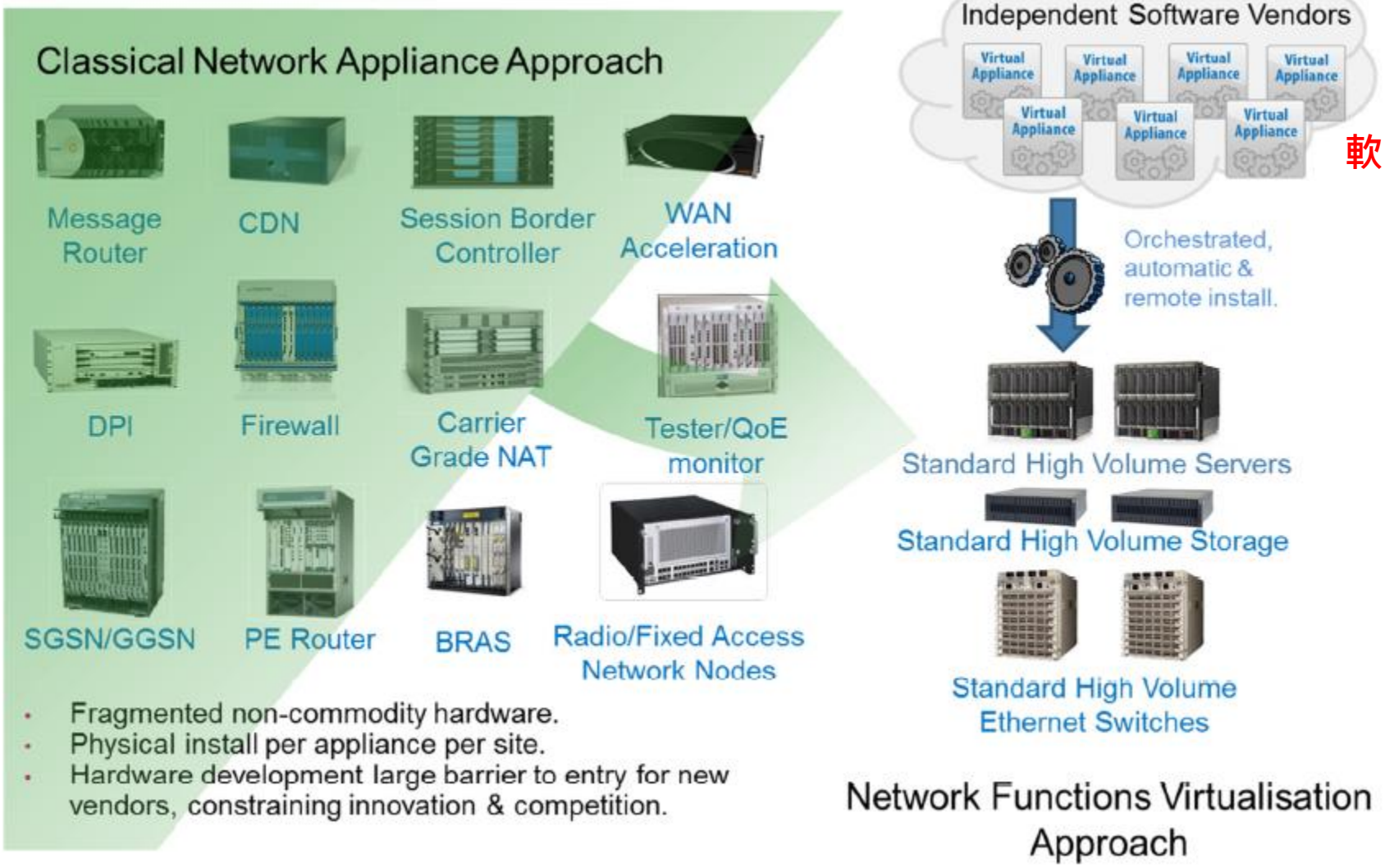
2013.01 成立
ETSI/ISG

CONTRIBUTING ORGANISATIONS & AUTHORS

AT&T:	Margaret Chiosi.
BT:	Don Clarke, Peter Willis, Andy Reid.
CenturyLink:	James Feger, Michael Bugenhagen, Waqar Khan, Michael Fargano.
China Mobile:	Dr. Chunfeng Cui, Dr. Hui Deng.
Colt:	Javier Benitez.
Deutsche Telekom:	Uwe Michel, Herbert Damker.
KDDI:	Kenichi Ogaki, Tetsuro Matsuzaki.
NTT:	Masaki Fukui, Katsuhiro Shimano.
Orange:	Dominique Delisle, Quentin Loudier, Christos Kolias.
Telecom Italia:	Ivano Guardini, Elena Demaria, Roberto Minerva, Antonio Manzalini.
Telefonica:	Diego López, Francisco Javier Ramón Salguero.
Telstra:	Frank Ruhl.
Verizon:	Prodip Sen.

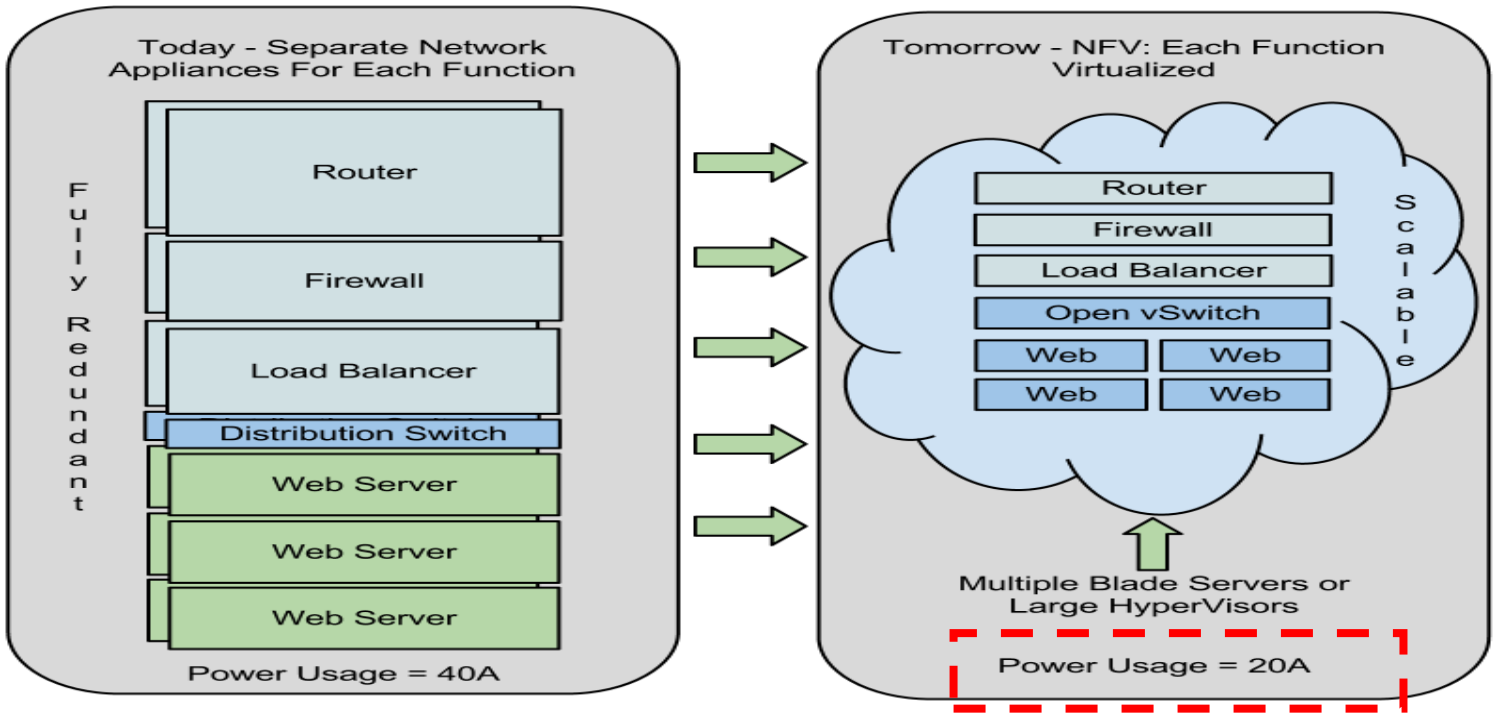
http://www.tid.es/es/Documents/NFV_White_PaperV2.pdf

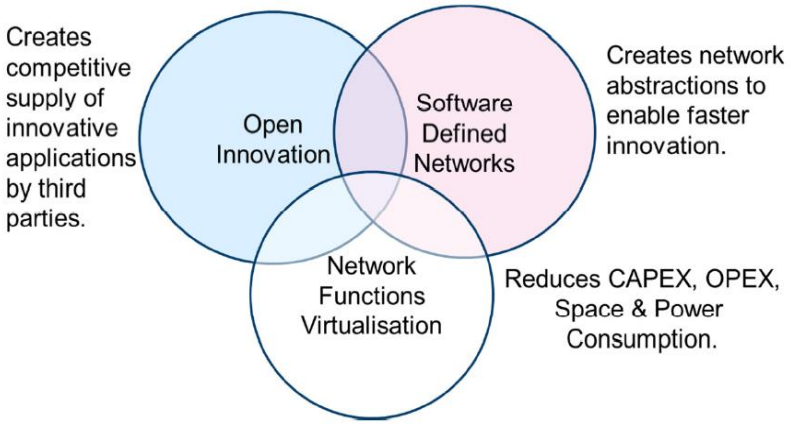
NFV 目標



http://portal.etsi.org/NFV/NFV_White_Paper2.pdf

Data Center NFV架構



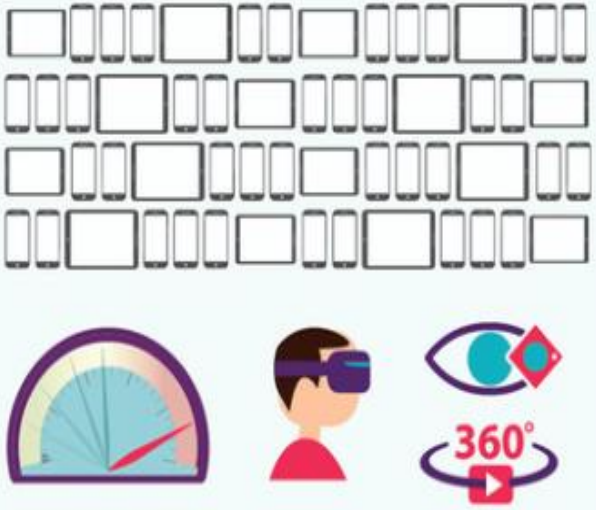


http://www.tid.es/es/Documents/NFV_White_PaperV2.pdf

5G 應用

高速上網,AR/VR

Enhanced
Mobile broadband
eMBB



Improved consumer experience
More connected devices
Faster connection speeds
Virtual and Augmented Reality

IoT物聯網

Massive
Machine type
communications
mMTC

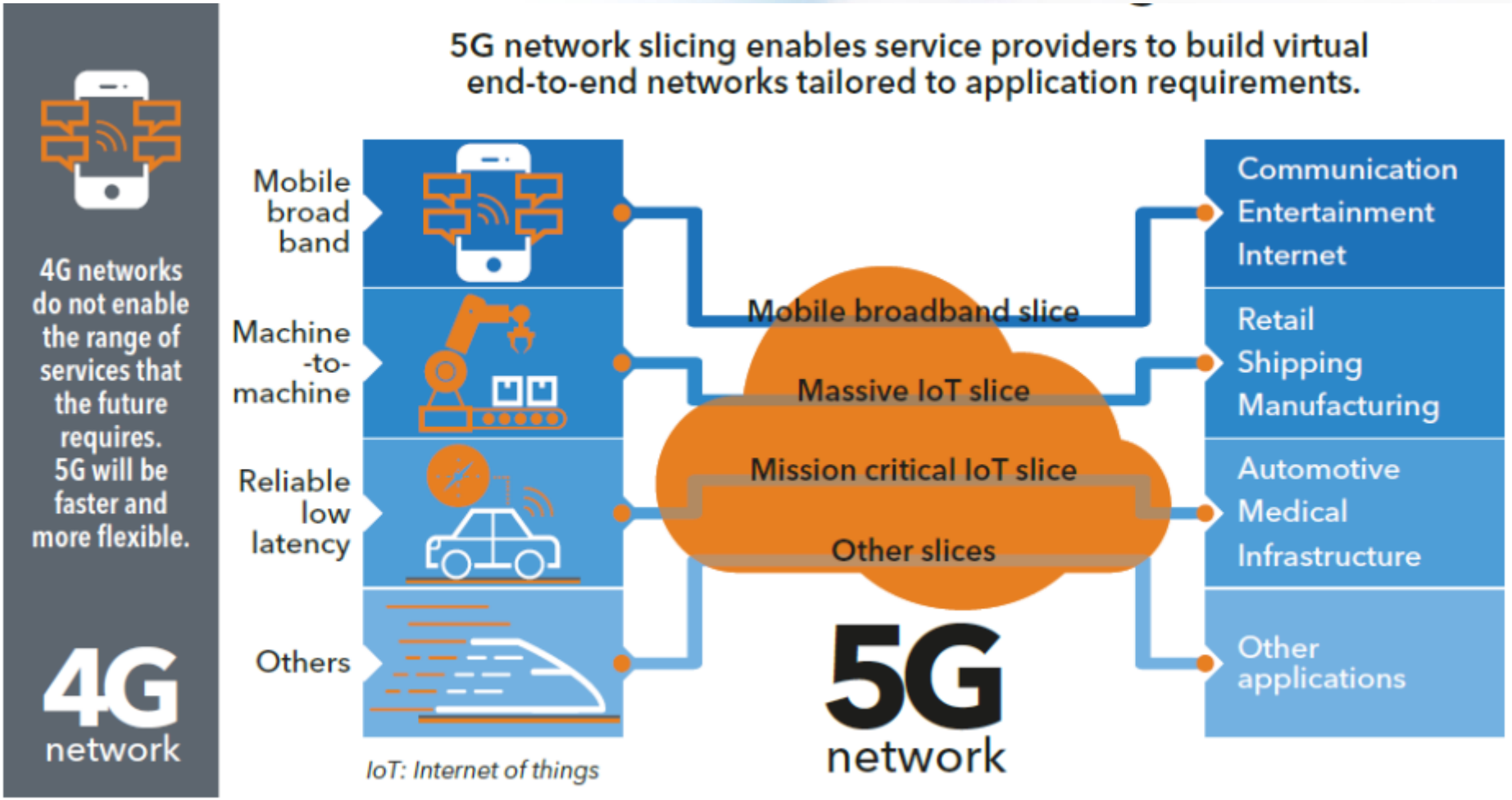
e-health
Transport & logistics
Environmental monitoring
Smart energy networks
Smart agriculture, smart retail

車聯網

Ultra-reliable
and low latency
communications
uRLLC

Vehicle-to-everything communication
Drone delivery
Autonomous monitoring
Smart manufacturing

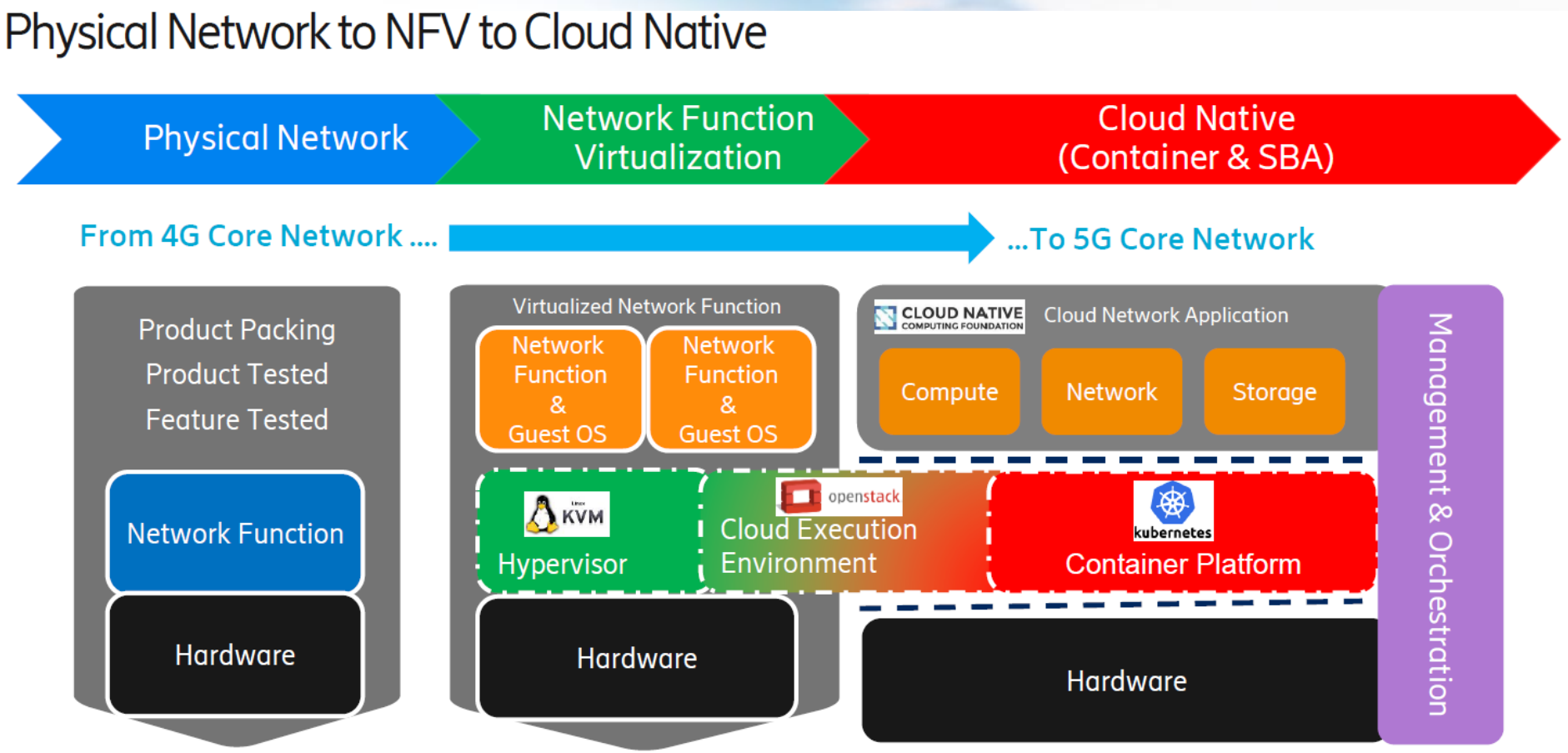
5G Network Slicing



Source: ITUNews

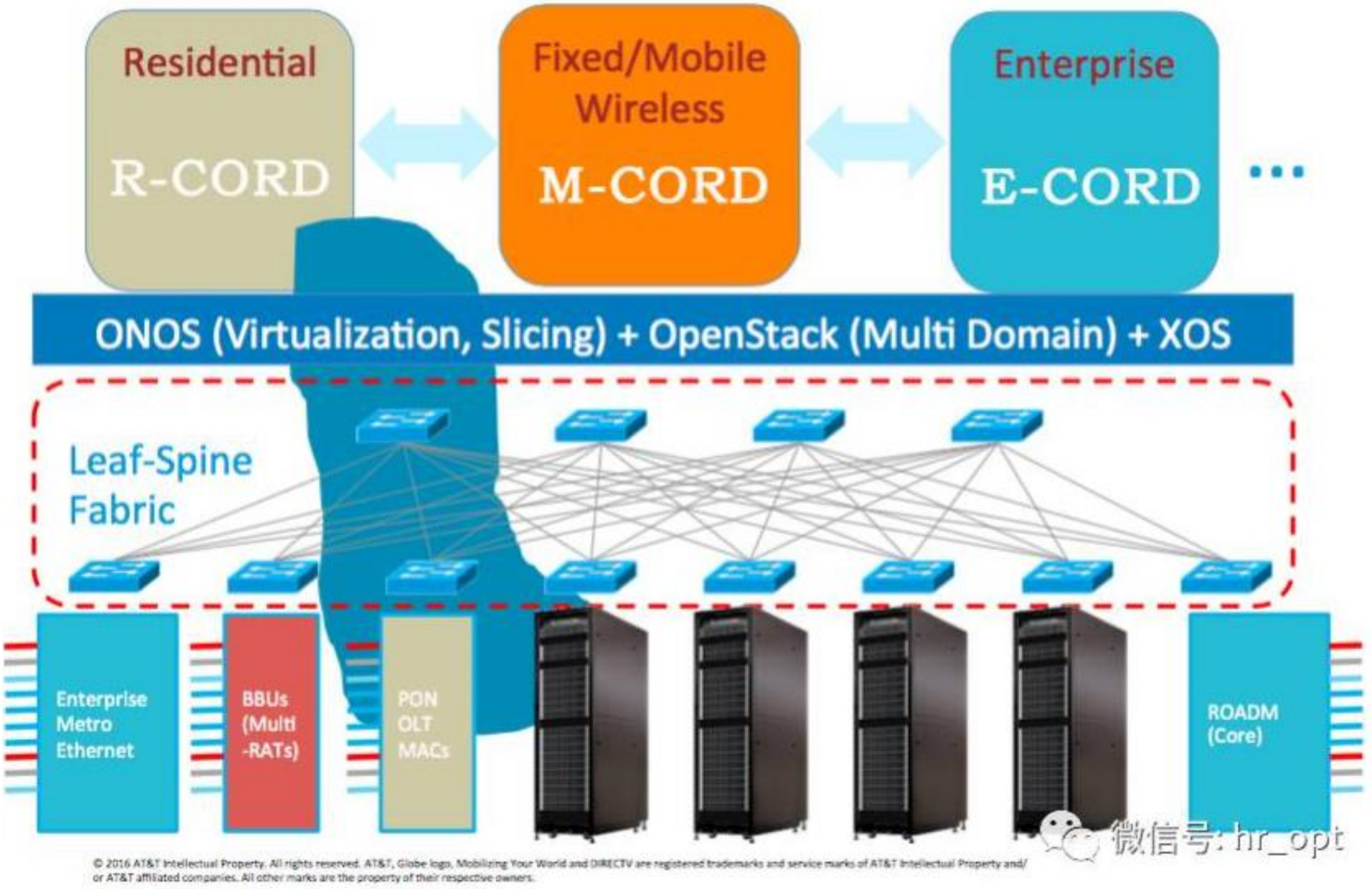
https://www.sdxcentral.com/5g/definitions/5g-network-slicing/

Mobile Network演進



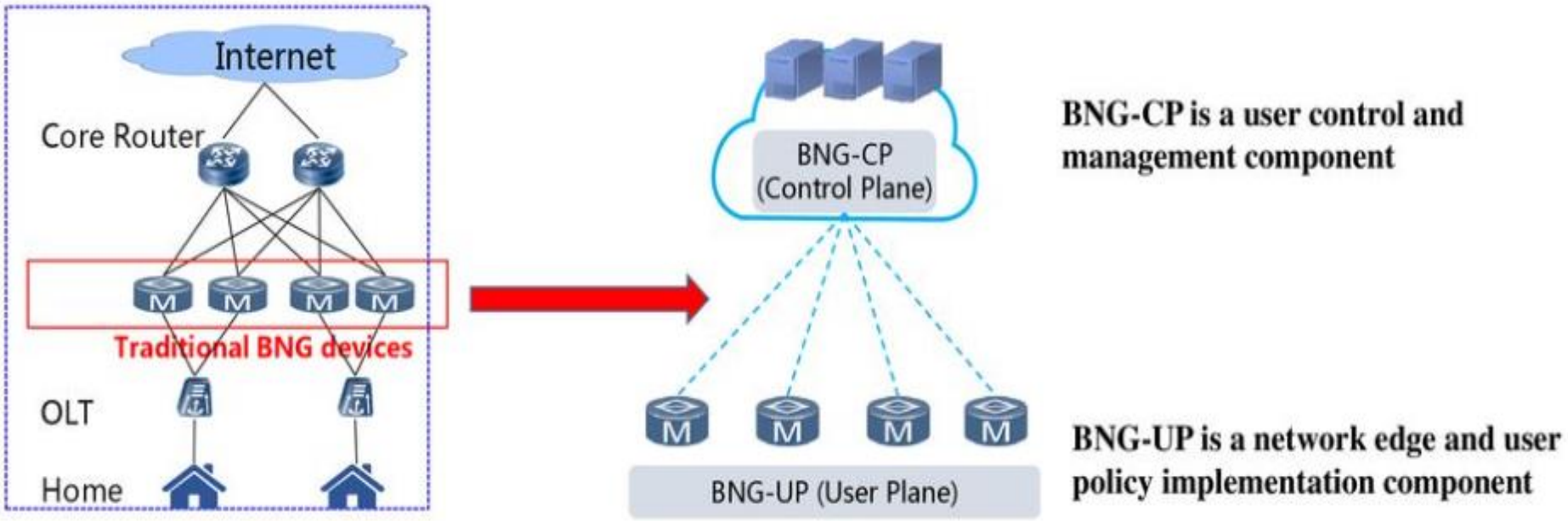
SBA: Service-Based Architecture

電信機房SDN/NFV 網路架構(重構)



CUPS案例: vBNG

CUPS: Control and User Plane Separation



Painpoints for tradition BNG

(1) Services are **not well balanced** in different parts resulting to different utilization of resources such as sessions and IP addresses

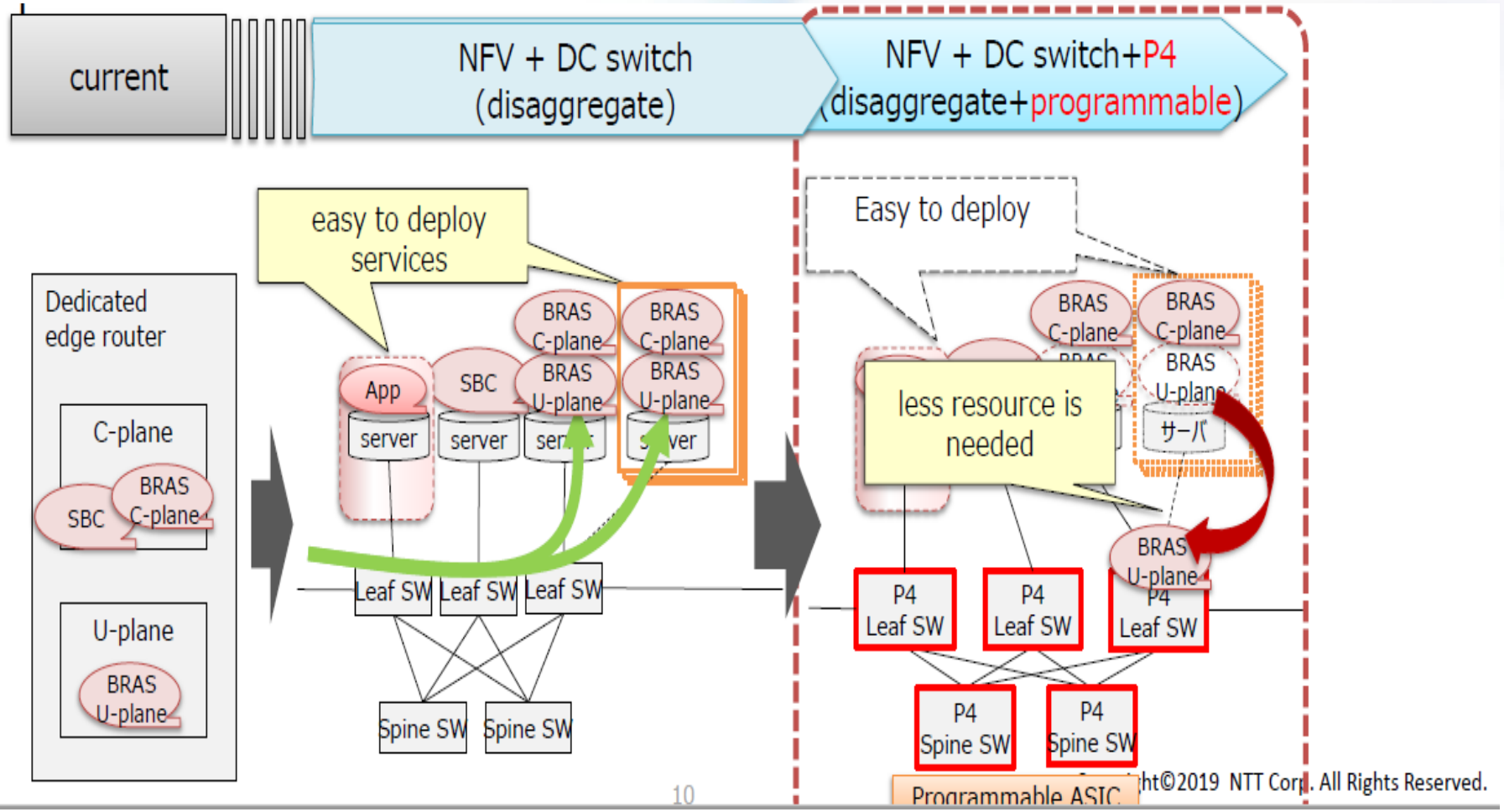
(2) BNG is evaluated by indicators some related with forwarding resources and some related with controlling resources. Both can be the limitation of a BNG device .

(3) BNGs are configured on each device. It's not convenient **on management**.

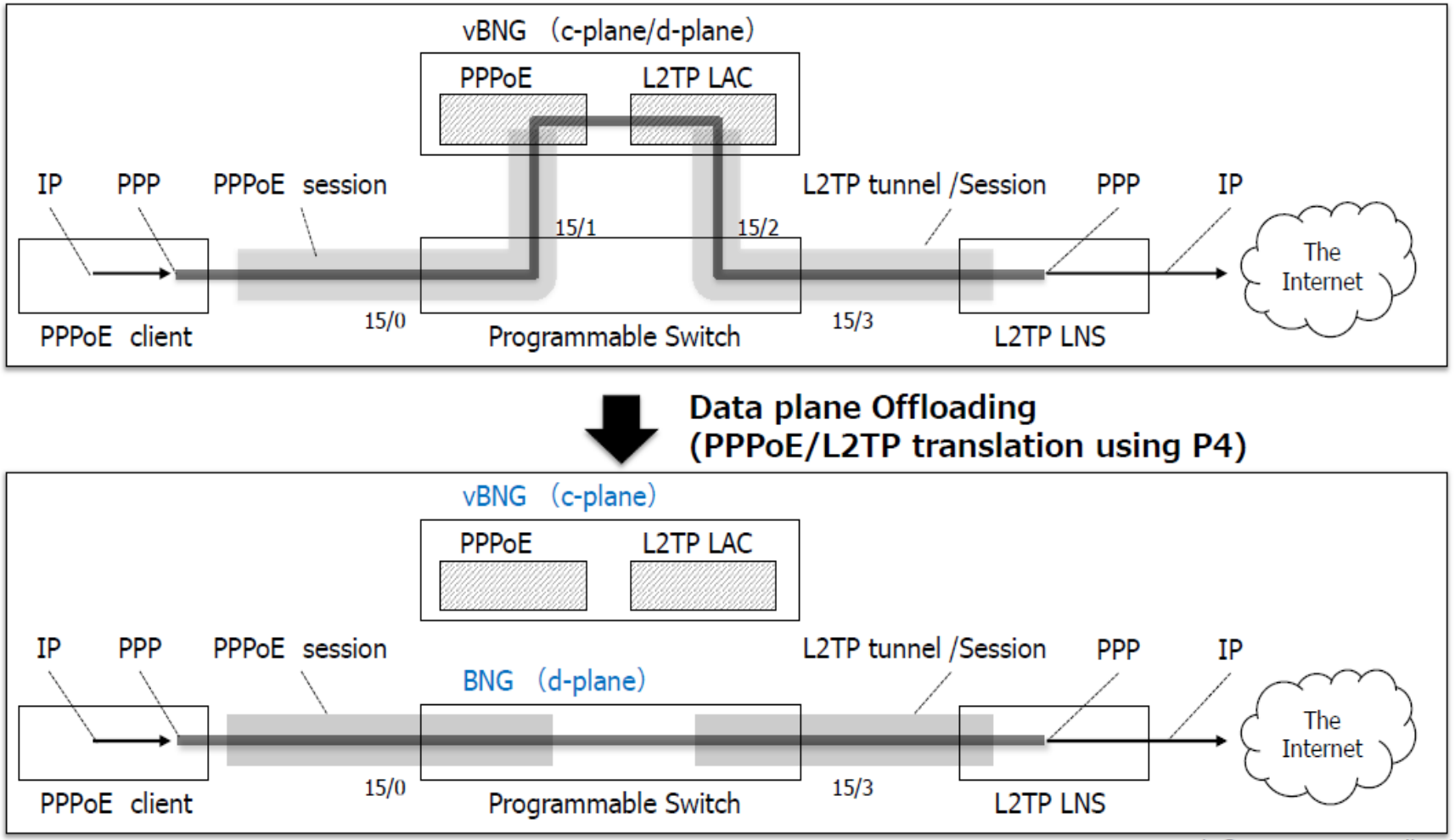
Source: https://slideplayer.com/slide/15213115/

vBNG (1/2)

CUPS: Control and User Plane Separation



vBNG (2/2)



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Chunghwa Telecom

智慧政府
基礎架構T-Road

Refresh your life

智慧政府規劃 基礎架構T-Road

基礎架構

- 以數位身分識別證(New eID)串連政府所有服務
- 建立具安全且可信賴(Secured- trust)的T-Road

三大目標

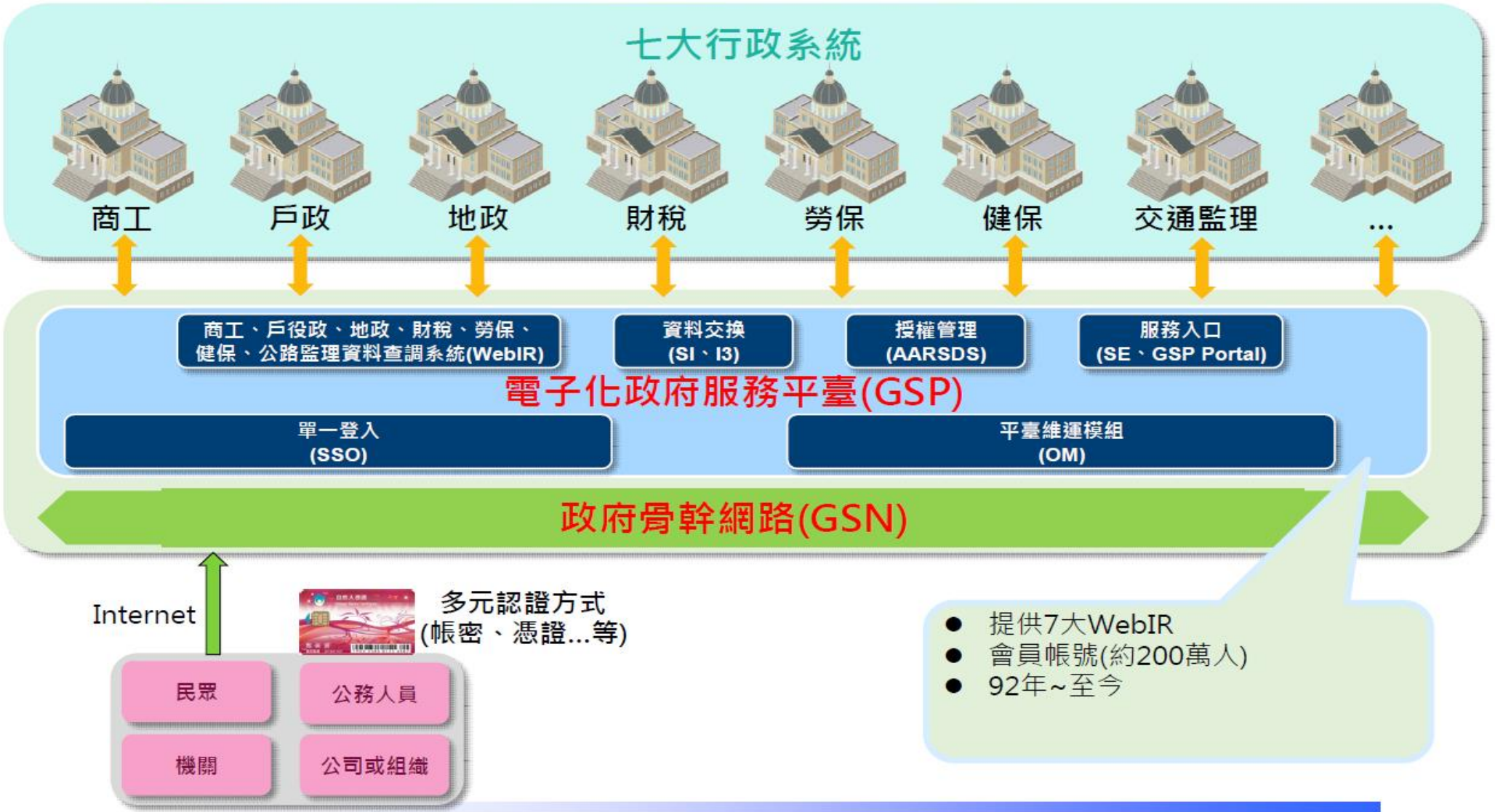
- 開放資料透明，極大化加值應用
- 鏈結治理網絡，優化決策品質
- 整合服務功能，創新智慧服務

三大配套措施

- 建置法規調適平臺
- 落實監督隱私保護
- 深化資安縱深防禦

建立具安全且可信賴(Secured-trust) 的T-Road

現行政府服務平臺(GSP)架構



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報告完畢
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