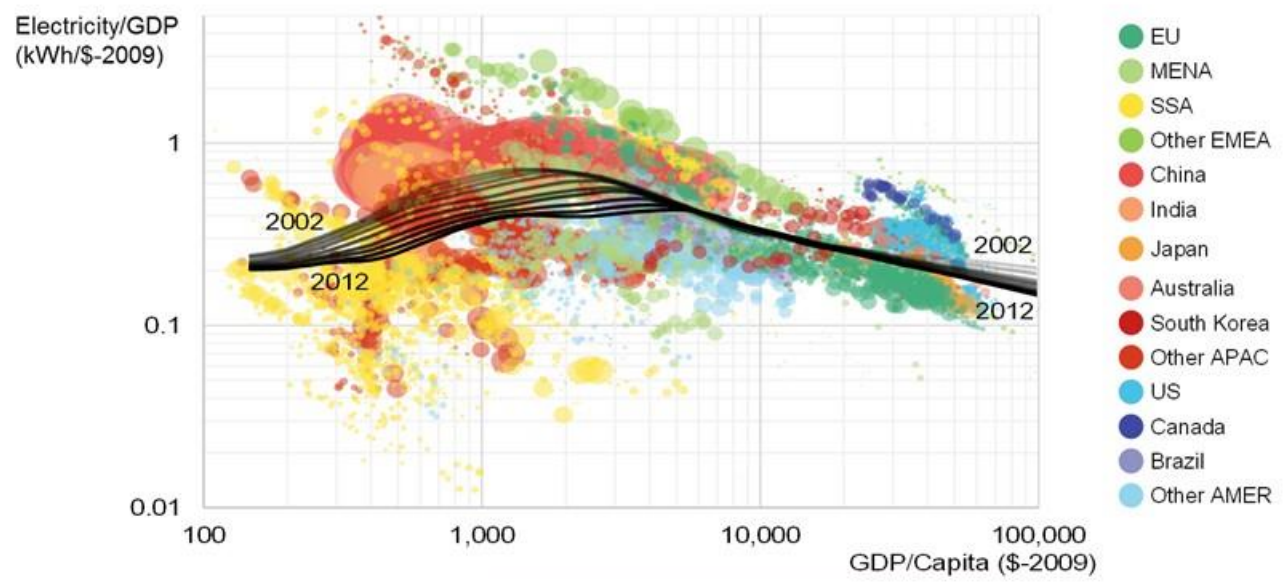
Beyond Cloud Computing

Network Transformation Project

November 2018

The world is changing …



GDP and Electricity demand decoupling

… and enel as a global utility, is reacting to the change

ENEL TODAY: a global leader

83° Fortune Global

~ 75 billion € of revenues
~ 15,6 billion € EBITDA

as of 2017

#1 network private operator in the world
71 million final users
2,2 million km of networks

#1 **renewable** operator in the world
42,5 GW managed capacity

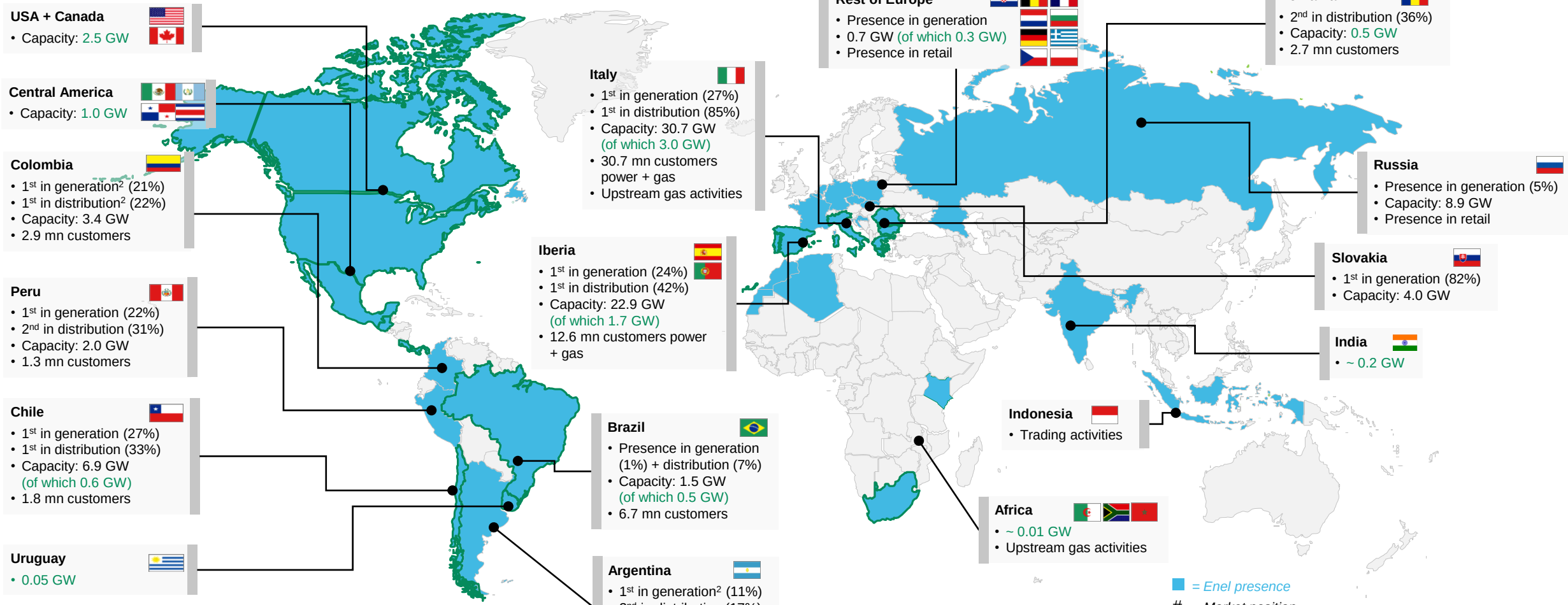
+20 M free **retail** customers
#1 in Italy, Iberia and top 3 in LatAm

46,6 GW **thermal** capacity
Carbon-neutral by 2050

Enel X: New business
(e-Mobility, e-Home, e-City, e-Industry)
+5.7 GW demand response

Enel today[1]

Global diversified player in more than 30 countries



USA + Canada
- Capacity: 2.5 GW

Central America
- Capacity: 1.0 GW

Colombia
- 1st in generation[2] (21%)
- 1st in distribution[2] (22%)
- Capacity: 3.4 GW
- 2.9 mn customers

Peru
- 1st in generation (22%)
- 2nd in distribution (31%)
- Capacity: 2.0 GW
- 1.3 mn customers

Chile
- 1st in generation (27%)
- 1st in distribution (33%)
- Capacity: 6.9 GW (of which 0.6 GW)
- 1.8 mn customers

Uruguay
- 0.05 GW

Italy
- 1st in generation (27%)
- 1st in distribution (85%)
- Capacity: 30.7 GW (of which 3.0 GW)
- 30.7 mn customers power + gas
- Upstream gas activities

Iberia
- 1st in generation (24%)
- 1st in distribution (42%)
- Capacity: 22.9 GW (of which 1.7 GW)
- 12.6 mn customers power + gas

Brazil
- Presence in generation (1%) + distribution (7%)
- Capacity: 1.5 GW (of which 0.5 GW)
- 6.7 mn customers

Argentina
- 1st in generation[2] (11%)
- 2nd in distribution (17%)
- Capacity: 4.4 GW
- 2.5 mn customers

Rest of Europe
- Presence in generation
- 0.7 GW (of which 0.3 GW)
- Presence in retail

Romania
- 2nd in distribution (36%)
- Capacity: 0.5 GW
- 2.7 mn customers

Russia
- Presence in generation (5%)
- Capacity: 8.9 GW
- Presence in retail

Slovakia
- 1st in generation (82%)
- Capacity: 4.0 GW

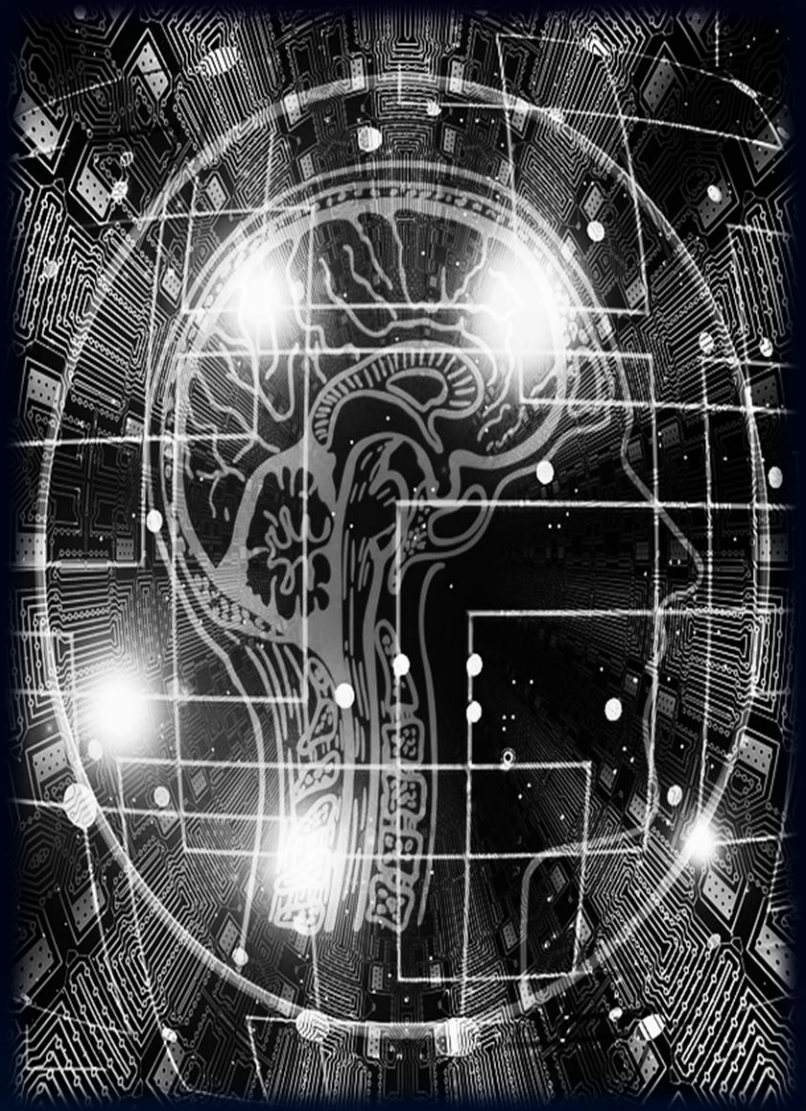
India
- ~ 0.2 GW

Indonesia
- Trading activities

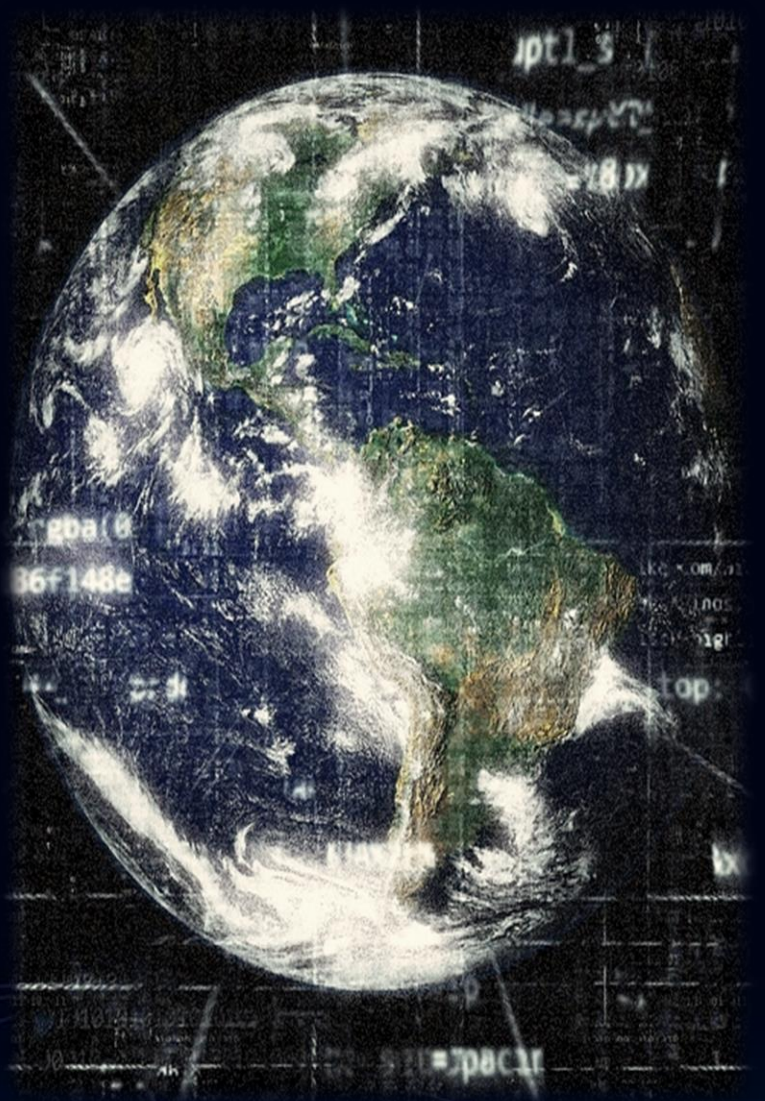
Africa
- ~ 0.01 GW
- Upstream gas activities

■ = *Enel presence*
\# = *Market position*
% = *Market share*
□ = *Renewable Energy*
GW = Renewable Energy Capacity

1. As of 31st December 2015; %, as of 31/12/2014
2. Among private operators



```
54  padding: 4px 6px;
55  text-align: left;
56
57  &:hover {
58      color: $c-link-hover;
59  }
60
61  &.selected {
62      background-color: $c-ac
63      color: white;
64  }
65
66  .amount {
67      float: right;
68      font-weight: bold;
69  }
```



Artificial Intelligence

Information Technology

Telecommunication

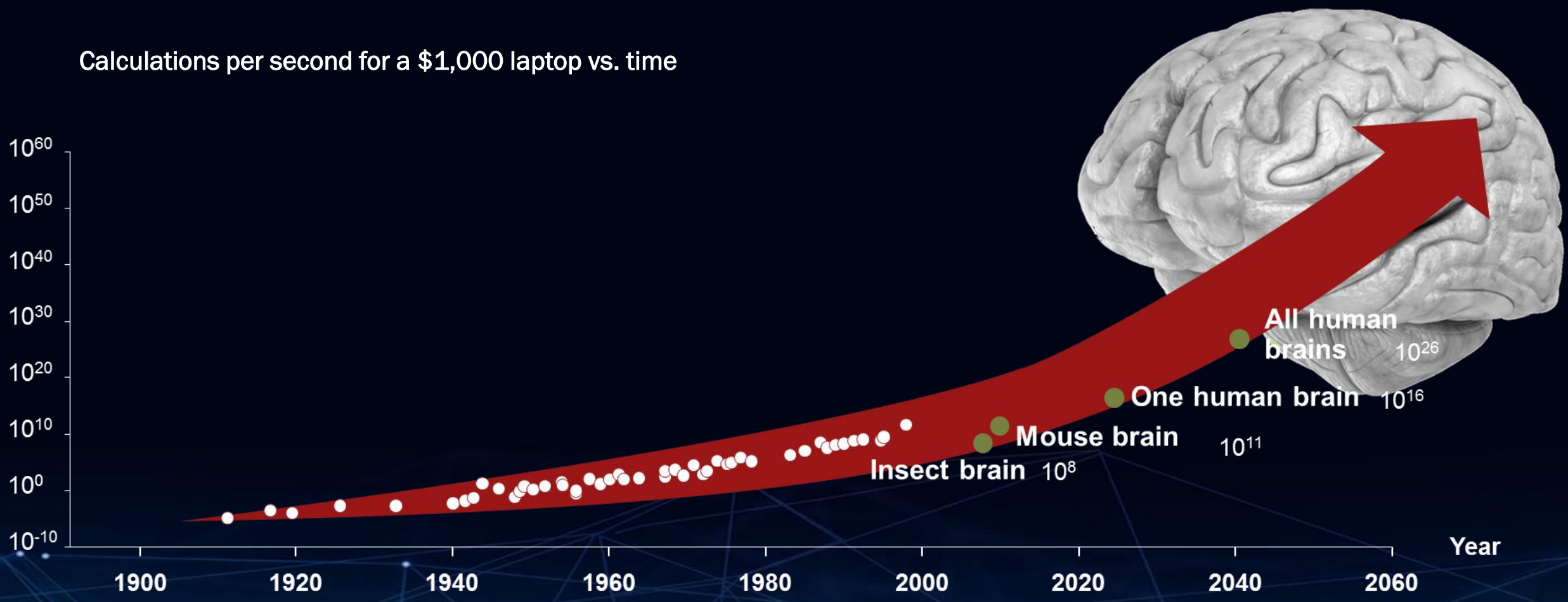
1956

1958

1962

Exponential increase

Calculations per second for a $1,000 laptop vs. time



Source: Peter Diamandis; A.T. Kearney

Beyond Cloud Computing

General concepts and project overview

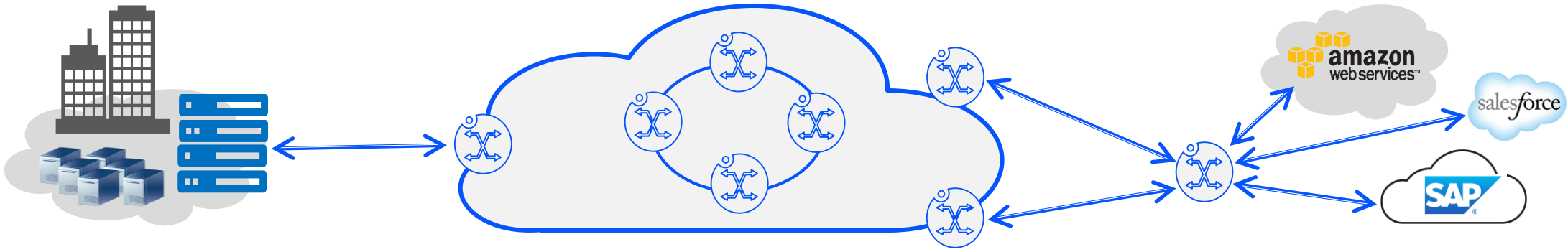
ENEL Cloud Journey

Exploring the Cloud	*New Applications*	CLOUD FIRST
Migration to Cloud	*Lift & Shift vsTransformation*	HYBRID CLOUD
Leveraging the Cloud	*Automation/Industrialization*	CLOUD ONLY
Beyond **Virtualization**	*Containers & Services (λ & IoT)*	SERVERLESS

Syndromes of the current model

The vertical approach

Branch Offices	Network	Cloud



“Local server farms”

Multiple appliances for networking **functions**, multiple **servers** for IT services and multiple **contracts** to manage all this.

“Ferrarify”

Based on **expensive** dedicated redundant links/hardware, **oversized** for critical applications but **undersized** for multimedia and public cloud services.

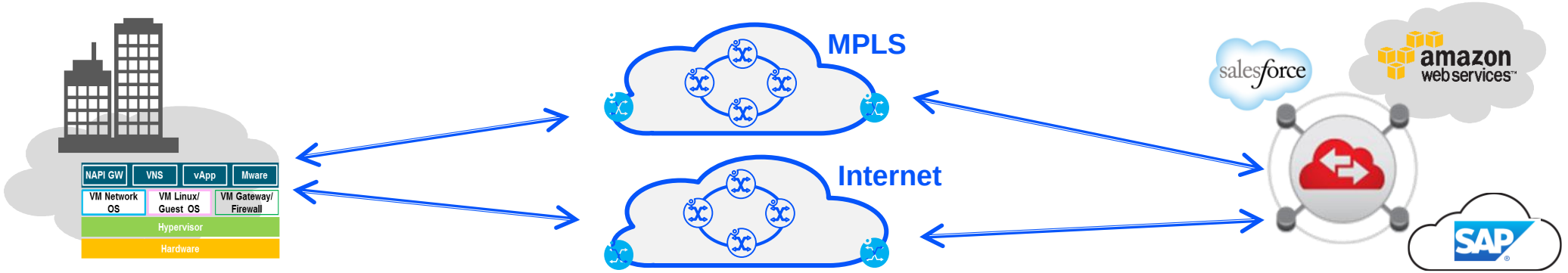
“Spaghetti links”

Rigid **cloud-dependent** connectivity. Expensive and with long provisioning times.

How to transform the current model?

Breaking Silos

Branch Offices	Network	Cloud



"Virtualization"

Consolidate multiple **appliances** and **services** in the same **generic hardware** (COTS x86 based).

"Commoditization"

Distribute traffic among high cost resilient **private networks** (MPLS) or among economic and every day more resilient **public networks** (Internet).

"Neutral facilities"

Exchanging traffic in **carrier neutral facilities** where all relevant **Telco Operators** and **Cloud Providers** are present.

Integrated end to end management and automation

ENEL - Beyond Cloud Computing Project

Executive Summary

Objectives

- ENEL is approaching a «*new way to think the Network*» a targetting a new model to guarantee
  - Overall **TCO reduction**
  - **Carrier Neutrality** at **Cloud Exchange** point
  - Reduced **vendor lock-in**
  - **Network agility** and **full programmability**
  - **Sinergy** with current «*Cloud Only*» program

The Study

- A **comprehensive and phased** business case has been run according to the following drivers
  - **Cost items aggregation** based on domain (Cloud Connectivity/CNF, WAN Aggregation; Regional Access, Network Functions and Network Management)
  - **Distributed in** three different phases with different scenarios (conservative and aggressive)
  - Time plan to address the new network layout **by the end of 2018**

BC Outcomes

- Business Case has been finalized with a good level of accuracy with the following results
  - **New Cloud connectivity strategy @CNF is** funding trasformation initiatives forecasted for the first phase
  - SD-WAN introduction costs at aggregation level are **strictly dependent** on international P2P decommissioning
  - Total TCO saving of vCPE roll-out phase **can be improved** with the following levers :
    - **Infrastructure cost offloading** through sinergy with other initiatives (EUS)
    - **Internet negotiation capability** at access costs **for Italy** (against current *Abraham II* contract)

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Starting a network transformation journey towards a full Open Network framework

Asset based architecture → Software defined architecture

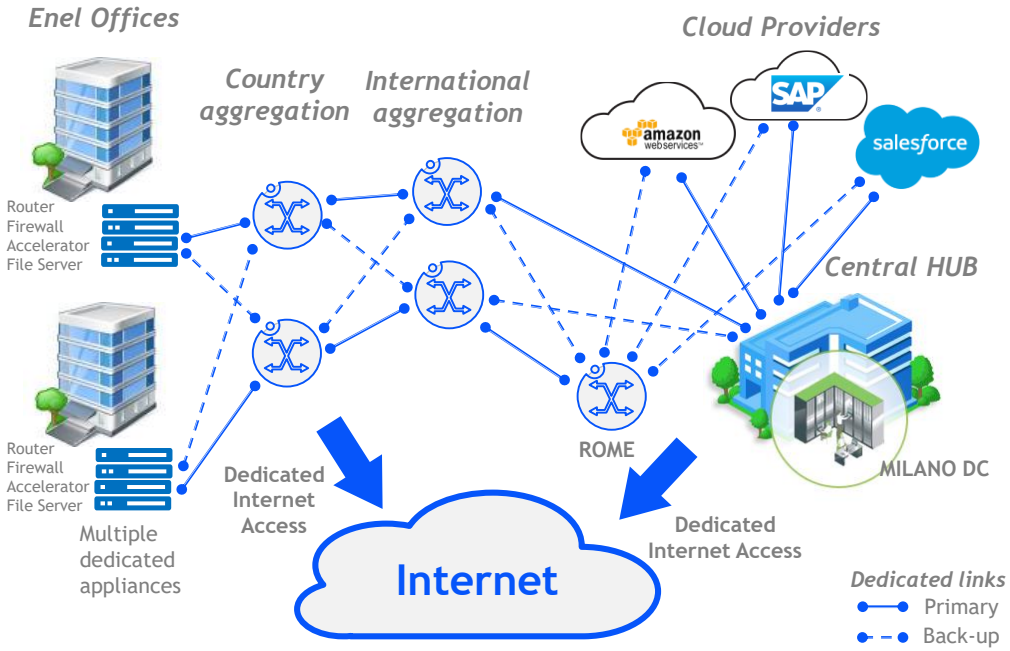
Dimensions

Connection to Cloud provider	**Network as constrain** for switching cloud provider	*CNF* — *Carrier Neutral Facilities*: Full interconnectivity between **multiple TLC carriers** and multiple **cloud provider**
Network provisioning	**Fixed owned network**	*SD-WAN* — *Software Defined Wide Area Network*: **Software-based**, fast and flexible provisioning
Network equipment	**Hardware** (Routers, switches …) **On premise**	*VCPE* — *Virtual Customer Premises Equipment*: **Software**, virtualized (no HW lock-in) **On cloud** / *remotization* network functions (e.g. firewalling)

Beyond Cloud Computing

Starting a network transformation journey towards a full Open Network framework

AS-IS Model

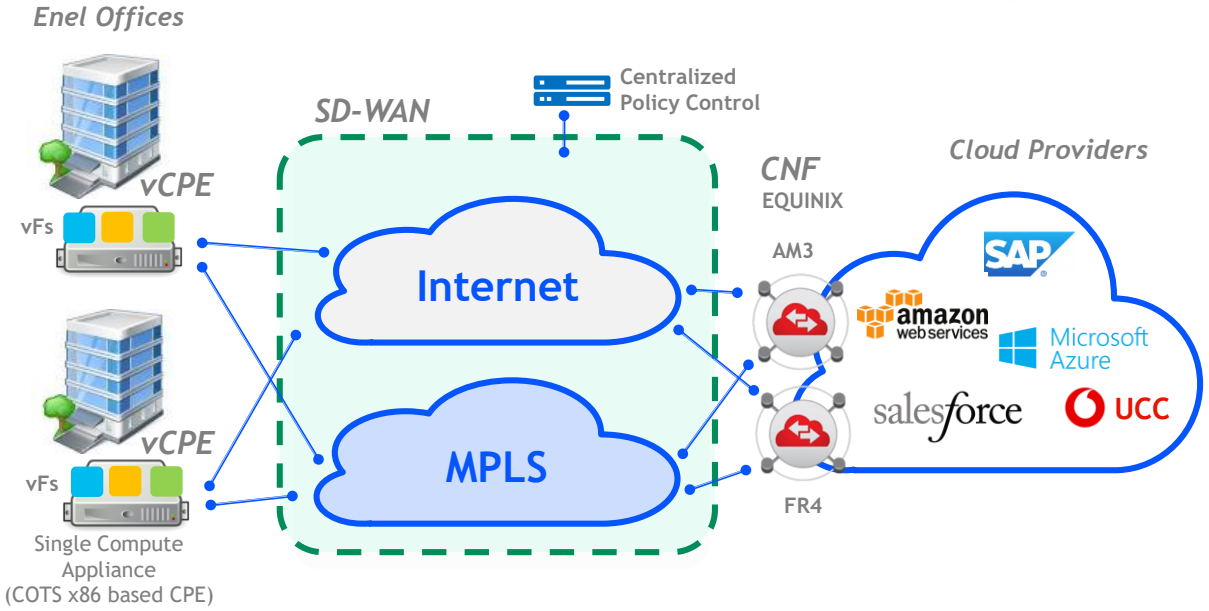


Drawbacks

- **Premises equipment**: Multiple **appliances** for networking functions, multiple servers for IT **services** and multiple **contracts** to manage them
- **Network: Fixed** and **static** paths (through a central HUB); Complex provisioning; **Bandwidth limitation** for cloud native services
- **Cloud**: Rigid **cloud-dependent** connectivity

TO-BE Model

Asset based architecture → Software defined architecture



vCPE
Virtual Customer Premises Equipment

Software, virtualized (no HW lock-in)
On cloud / *remotiza-tion* network functions

SD-WAN
Software Defined Wide Area Network

Software-based, fast and flexible provision
Technology access **agnostic** (ADSL, LTE, fiber)

CNF
Carrier Neutral Facilities

Full interconnect. between **multiple TLC carriers** & **cloud providers**

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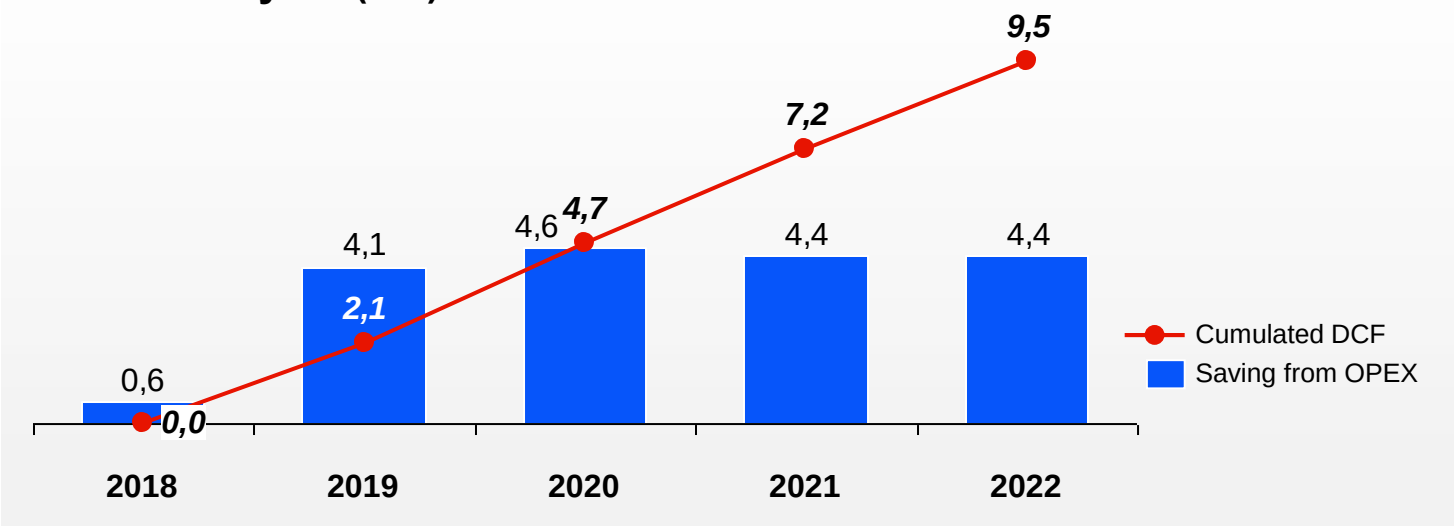
Business Case

Cash flow analysis (M€)



2018-2022 Total (M€)	
Capex To Be	12,48
Opex To Be	47,45
Capex As Is	12,48
Opex As Is	65,57

Main Evidences

- **NPV ~** 9,5 M€ (WACC 6,82%)
- **Self-financing** initiative (through already defined inertial Capex) producing positive cash flows starting from 1st year
- **Saving** opex at steady state 4,4 M€ (~33%)

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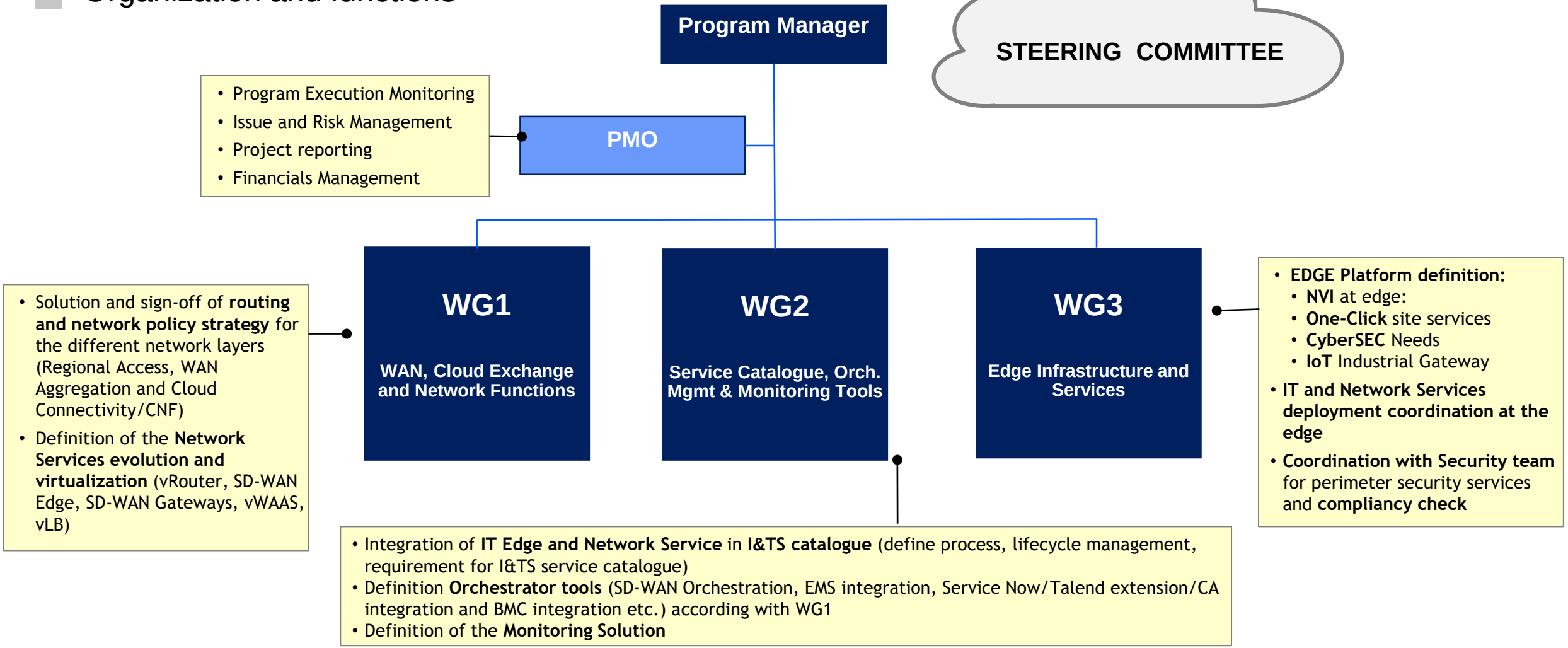
Organization and functions



Deployment will be done through assurance teams (PIM, NCO, GD)

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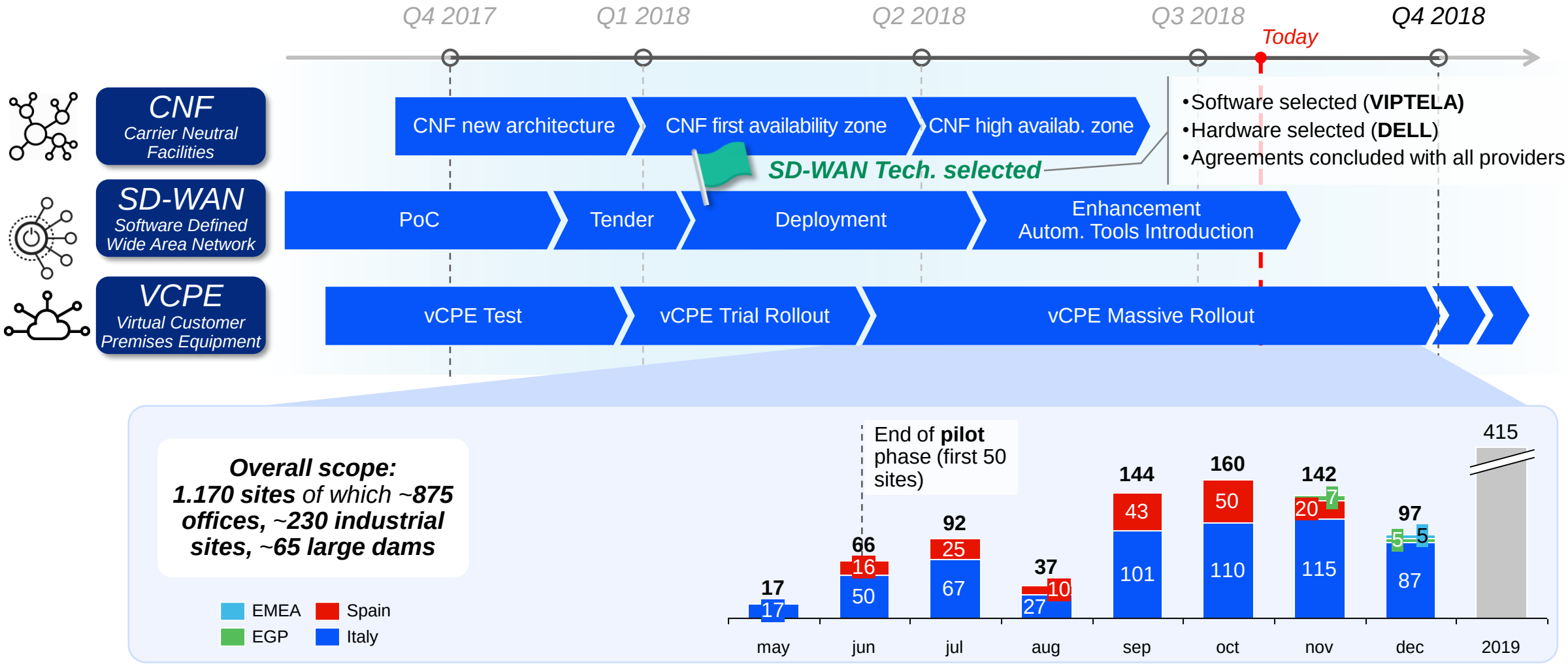
High Level roadmap



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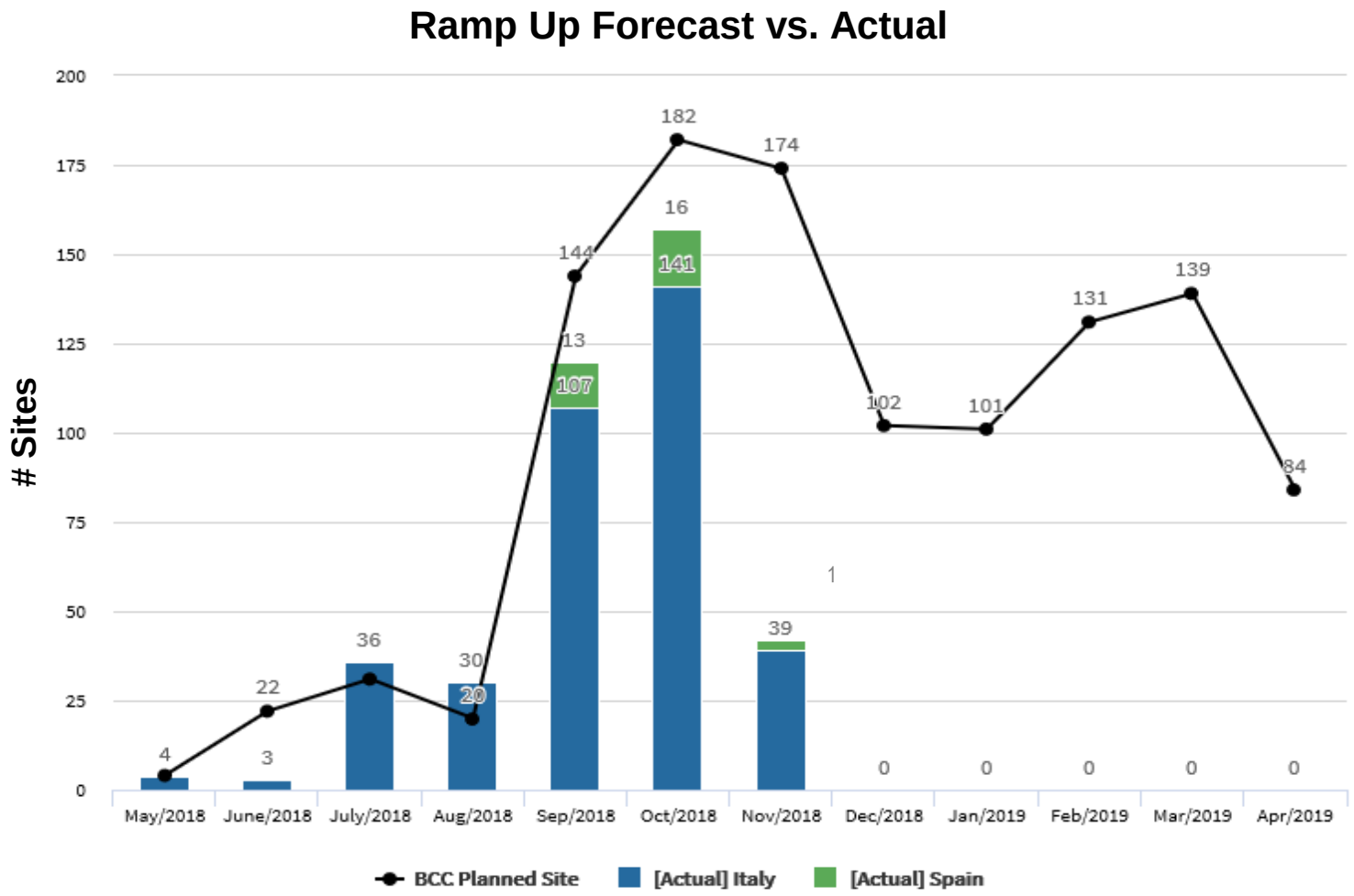
Massive deployment status



- Until 12 installations per day
- Site migration time from 5 to 10 minutes, confirming a really Zero Touch Provisioning process
- 685 installations forecasted by end 2018

Beyond Cloud Computing

Cloud connectivity – CNF details

Cloud Connectivity Evolution

CNF – Carrier Neutral Facilities. Main drivers

- **Consolidate** the distributed accesses in Frankfurt for ENEL Cloud Environments (AWS, SAP, Salesforce) all in a single Cloud Exchange Site identifying a Carrier Neutral Facility (CNF) provider.

- **Co-Locate ENEL equipment devices** in the CNF to maintain the management of interconnection cloud-to-cloud and cloud-to-site, leveraging also on an **Out-of-Band Management** (OOBM) access.

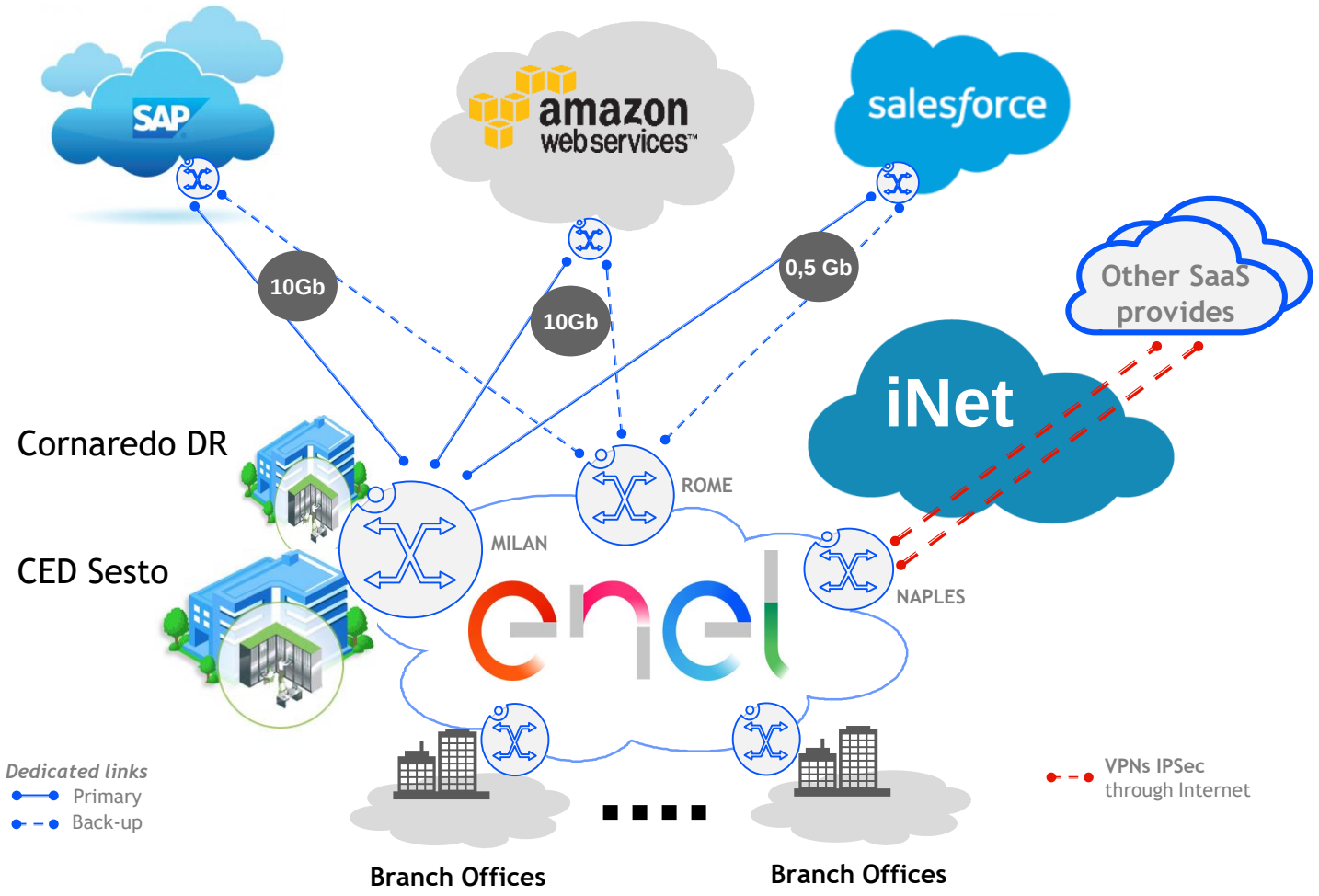
- **Optimize Cloud-to-Site connectivity** transforming actual architecture with **Point-to-Point links** between the CNF and the main Country PoPs (Milan, Rome, Madrid, Barcelona, Nutley, Hortolandia) offered by a **Telco Provider**.

- **Optimize link utilization** by load-balancing traffic and allowing traffic sharing across the redundant links, move from active/standby to active/active.

- **Easy access** to Cloud providers and Telecom operators and provide **Cloud redundancy** to access ENEL Environments leveraging on the CNF dark fiber.

Cloud Connectivity

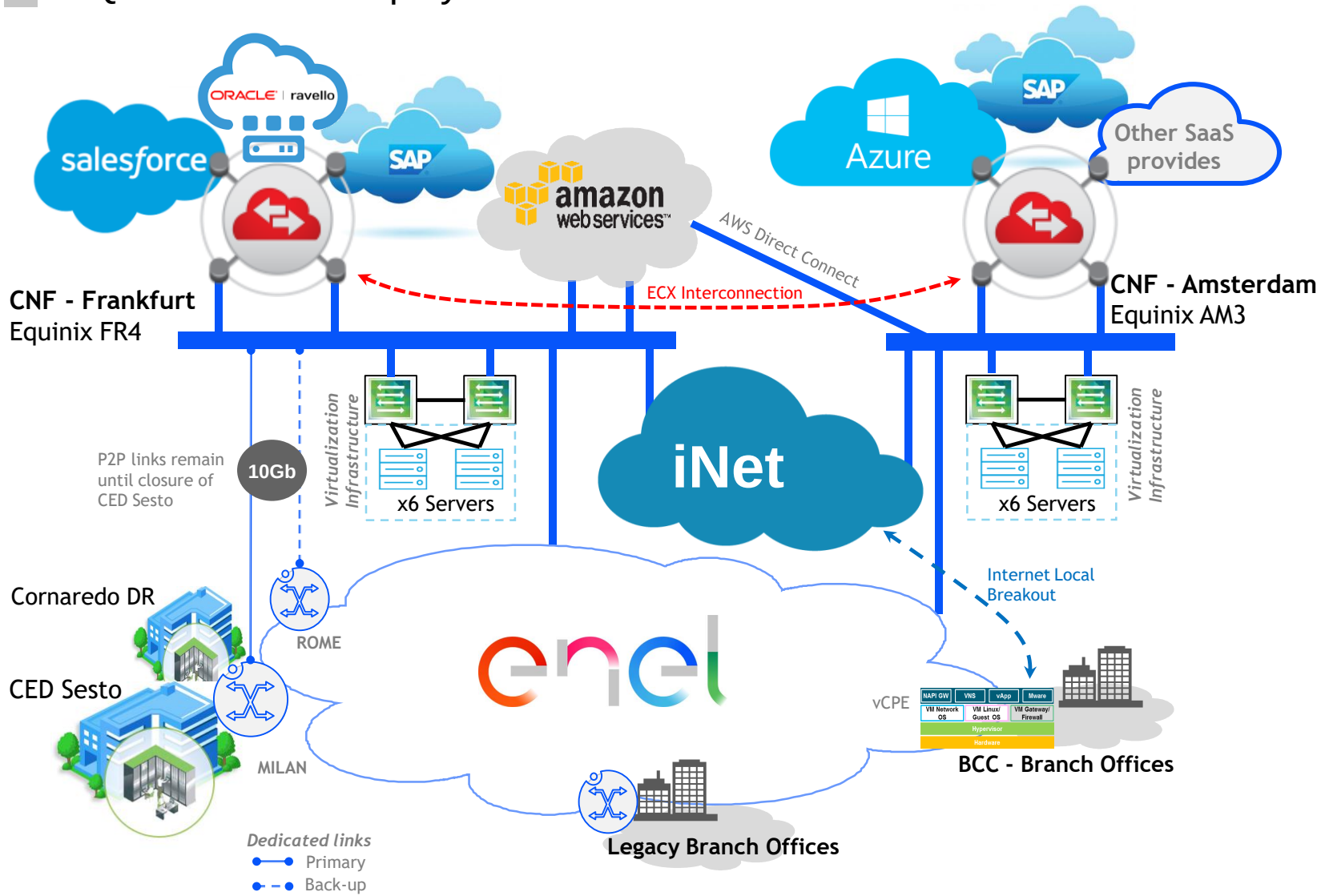
AS-IS before Beyond Cloud Computing project



- CAPEX model to **assure** the **cloud first**
- Oversized appliances and links.
- AS-IS **model** has a **reduced scalability**.
- AS-IS **network** is **cloud dependant**.
- Deterministic path ***Cloud2Cloud*** and ***Cloud2Site*** crossing Milan or Rome (active/standby), **adding** 19 to 29ms **latency** for regional clouds.

Cloud Connectivity

EQUINIX - CNF deployment



- Regional ***Cloud2Cloud*** latency 5 ms
- BCC sites have direct access to Internet and to Clouds impacting on a latency reduction for ***Site2Cloud*** traffic:
  - EU sites around 5-10 ms.
  - LATAM sites around 19-29 ms.
- Different high availability solutions:
  - AWS – Direct Connect based.
  - Salesforce – Equinix Cloud Exchange (ECX) based.
  - SAP high availability based on DR site and local redundancy.
- New Cloud providers SaaS or Pass easily connected (Ravello/Azure).
- Enable ***user2cloud*** use case by direct access to cloud using virtualization infrastructure.

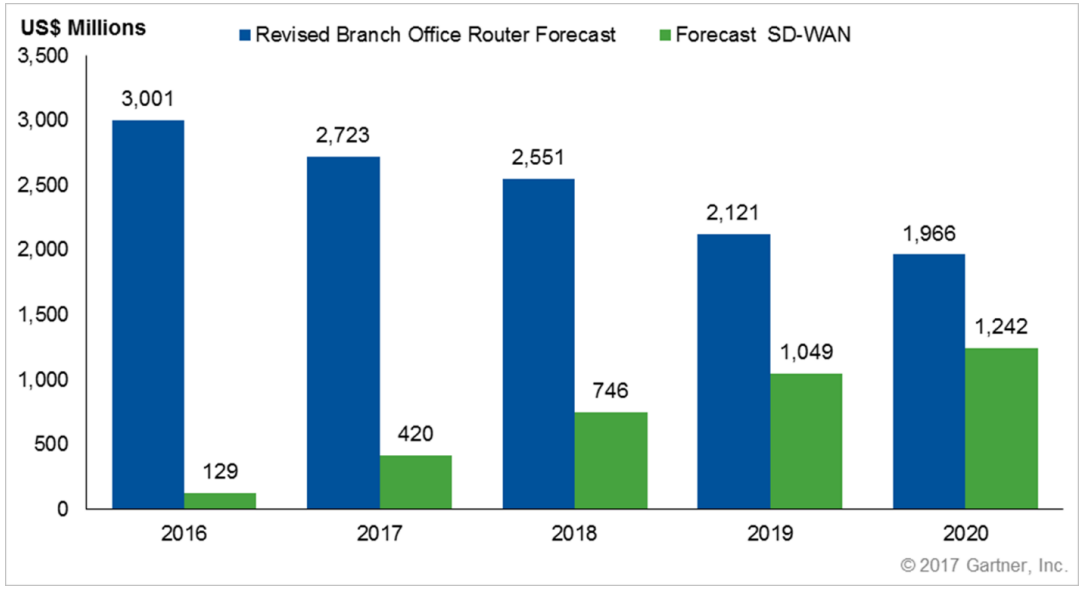
Beyond Cloud Computing

SD-WAN concepts and solution overview

SD-WAN Adoption

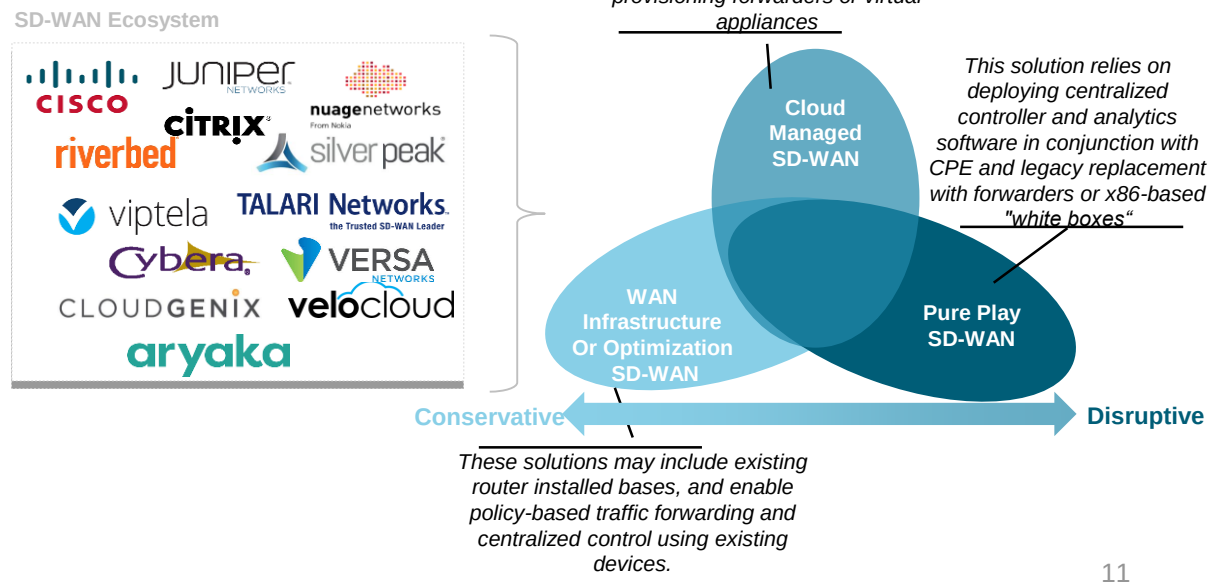
By 2020, more than 50% of WAN edge infrastructure refresh initiatives will be based on SD-WAN versus traditional routers

- As of March 2017, it's estimated there are over 3,000 paying SD-WAN customers, with more than 80% of those in production, including more than 100,000 total branches
- It's forecasted SD-WAN to grow at 59% compound annual growth rate (CAGR) through 2021 to become a $1.3 billion market



Source: Gartner (April 2017)

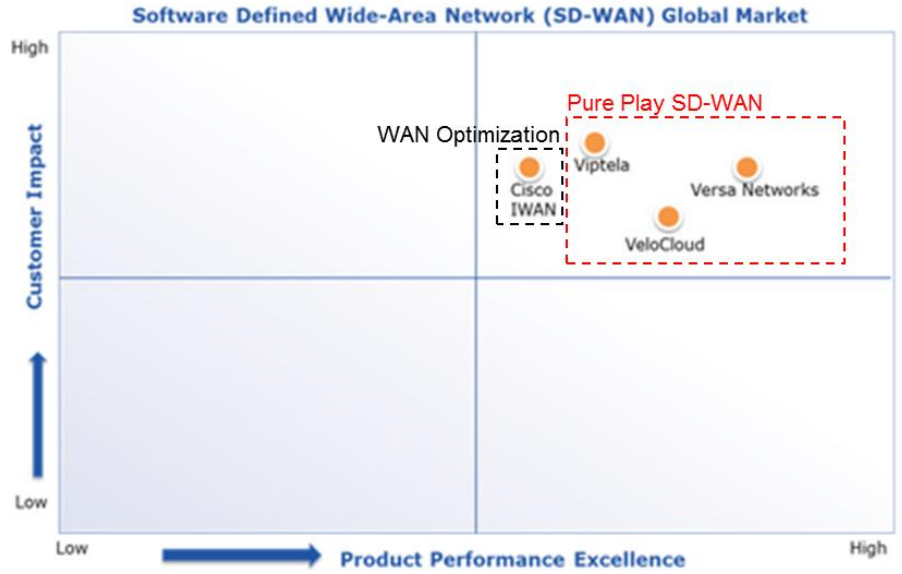
- As of April 2017, there are more than 30 vendors that provide SD-WAN capability.
- This includes pure-play SD-WAN startups (such as Talari, VeloCloud and Viptela), Cloud-managed SD-WAN vendors (such as Cloud-Genix, Aryaka) and established router incumbents (such as Cisco).



SD-WAN Global Market Quadrant

Initial scouting

- Below a Quadrant's competitive analysis of the SD-WAN market compares SD-WAN vendors' products and solutions capabilities in supporting different use cases.
- Quadrant analyzed vendors in terms of product portfolio, product innovation, sophistication of technology, competitive strategy, and customer impact.



Source: Quadrant Knowledge Solutions, 2017

- SD-WAN vendors are scrambling to grab market share as IHS Market Analysis Company reports in the following table
- According to the IHS Technology Data Center Network Equipment Quarterly Market Tracker report, there was a total of $36 million in SD-WAN revenue during the first quarter of 2017.

Competitive Set

	COMPANY	EMPLOYEES	TOTAL FUNDING ($)	REVENUE ($)
Acquired by VMware	VERSA NETWORKS	120	57.4M	10M
	velocloud	141	83M	7M
Acquired by Cisco	CLOUDGENIX	42	34M	6.5M
	viptela	156	108.5M	35M
	TALARI Networks.	112	33M	15.8M
	nuagenetworks	114	--	16.3M
	aryaka	292	142.2M	10.3M

Source: SDx Central, Top SD-WAN Vendors Based on Revenue in Q1 2017

SD-WAN – Vendor Selection and Comparison

SELECTION

The enterprise WAN edge has become the focus of new architectural approaches, in addition to functional consolidation, which has attracted more than 40 competitors. Technology product management leaders will be challenged as solution evolution will take multiple paths.

Considered Shortlist	Target Market	Network Size	Channel Strategy	Geography Sales	# of Customers	PER Behavior
VERSA NETWORKS	Large and Service Providers	Medium to Large	Providers	Global	100	R
velocloud	Medium to Large and Service Providers	Medium to Large	Direct, Providers	Global	>550	R
viptela	Medium to Large and Service Providers	Medium to Large	Direct, Providers	Global	<150	R
CLOUDGENIX	Medium	Small to Large	Direct, Channel	North America	<100	R
nuagenetworks	Large Service Providers	Medium to Large	Direct, Providers	Global	~50	E
aryaka	Small to Medium	Small to Medium	Direct, Channel	Global	>400	E

Source: Gartner, Competitive Landscape: WAN Edge (May 2017)

P: Protector
E: Evolutionary Disruptor
R: Revolutionary Disruptor

COMPARISON

- A «qualitative» comparison of different SD-WAN Vendors is represented in the Spider Graphs
- The qualitative score has based on the published technical documentation and related analysis on how they could address Project technical requirements

Edge Device
Virtualization
Site Deployment
Edge Configuration
Access Options
Basic Routing Capabilities
Advanced Routing Capabilities
Traffic Rates
Traffic Steering
Application Awareness
User Experience
Management
E2E Orchestration
Analytics & Reporting
Export to SIEM
Cloud Connect

SD-WAN – Software Defined Wide Area Network

How it works

Background

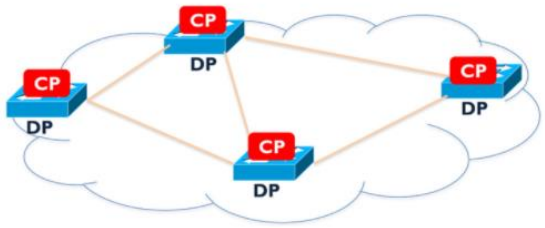
Before we send bus drivers out, we need to have a plan.

Control Plane = Learning what we will do

Data Plane = Actually moving the bus based on what we learned.

Traditional Network

Each device owns both **Control & Data Plane.** Usually integrated in device firmware



- Consistency needs to be maintained
- Changing routing policy takes time
- Traffic prioritization becomes a challenge
- Network configuration is almost static

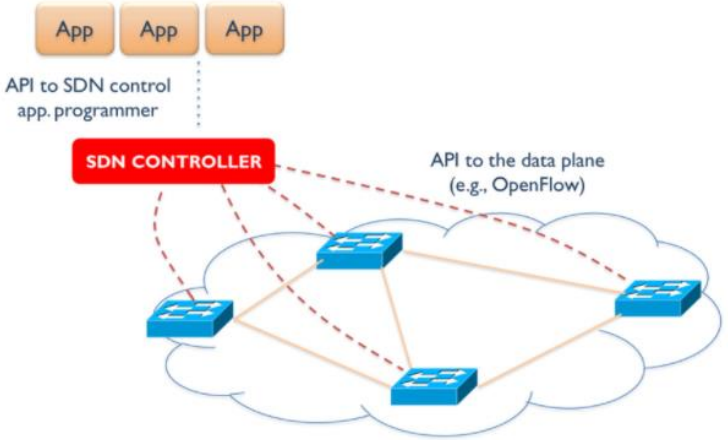
SD-WAN Network

Control Plane & Data Plane become two different entities.

Control Plane becomes centralized, one entity manages all the devices.

Control Plane can expose API, becoming a platform for next generation applications.

Data Plane still be in remote location, on the devices focused on managing physical connectivity.

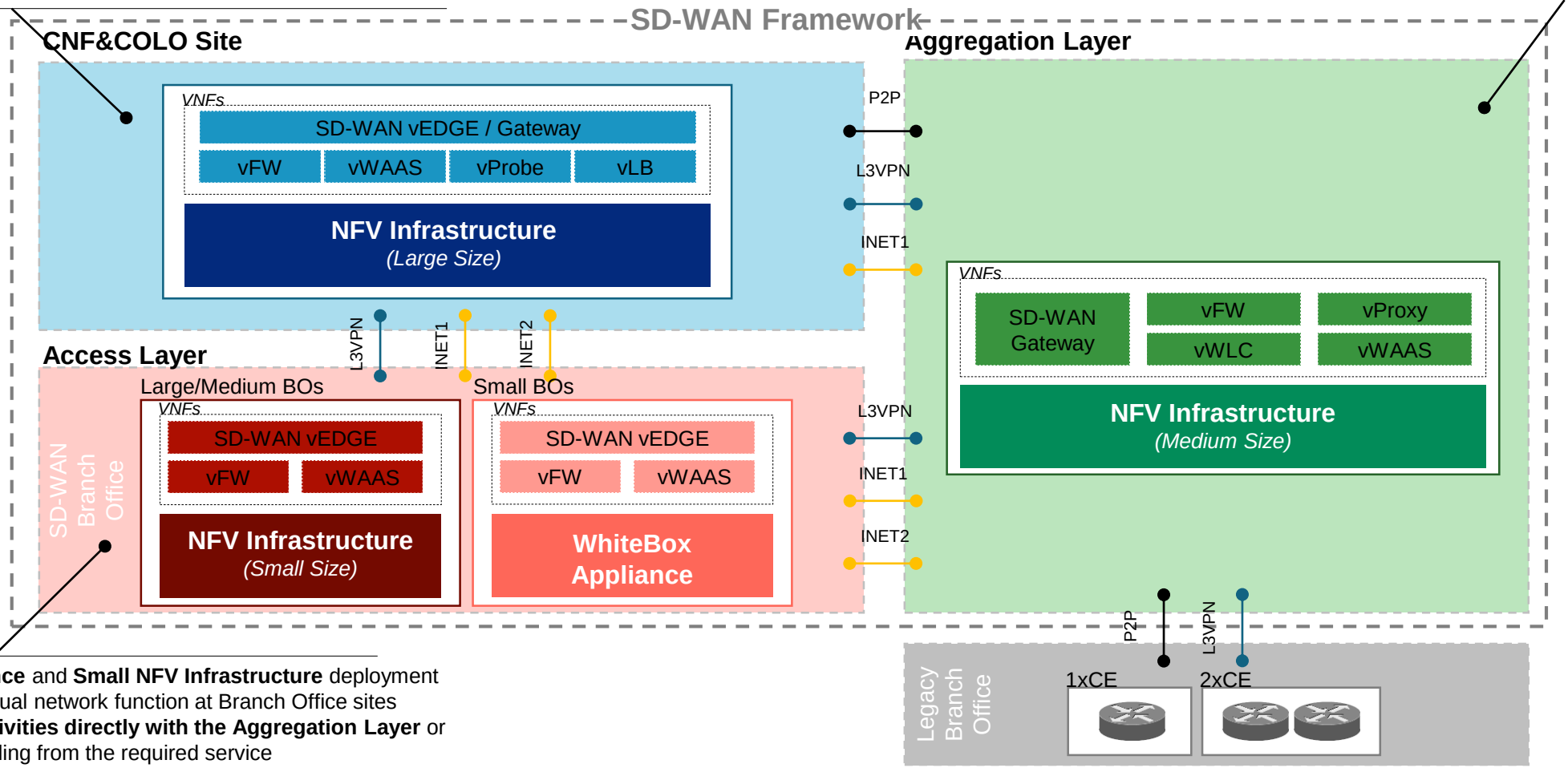


Network Evolution

SD-WAN Target framework and site layout

- A **large NFV Infrastructure** deployment to provide virtual network functions for Shared Services (vFW, vProbe, vWAAS)
- **vEDGE** to interconnect remote Branch Office and WAN Aggregation Layers via SD-WAN

- A **medium NFV Infrastructure** deployment to provide virtual network functions for Local Branch Offices (vFW, vWAAS, vWLC, vProxy)
- **SD-WAN Gateway** function to manage local SD-WAN connectivities and interconnection with underlay network



- **Whitebox Appliance** and **Small NFV Infrastructure** deployment to provide local virtual network function at Branch Office sites
- **SD-WAN connectivities directly with the Aggregation Layer** or Cloud Site, depending from the required service

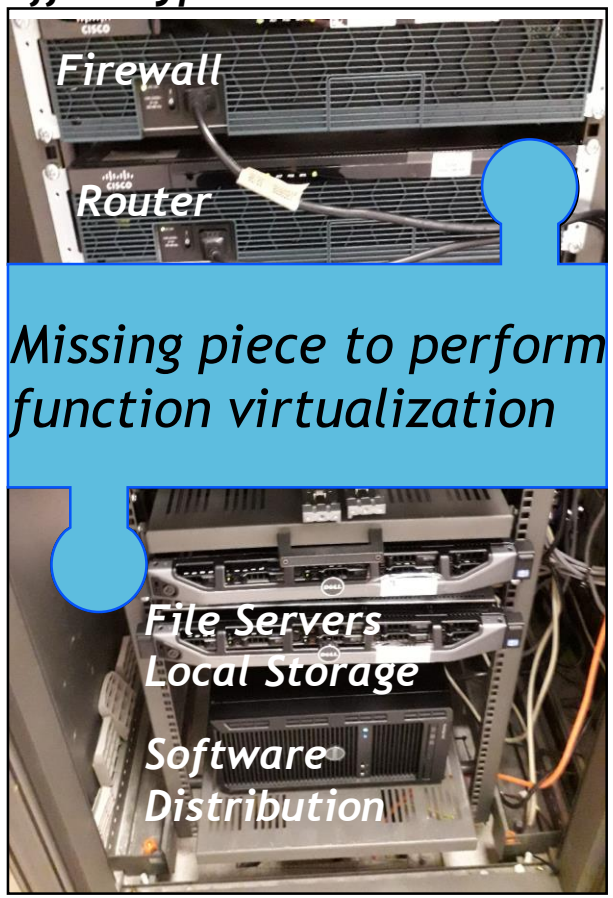
Beyond Cloud Computing

Functions Virtualization concepts

Network Function Virtualization

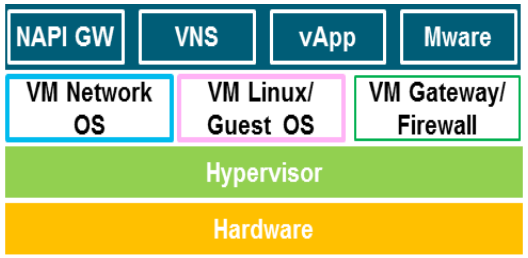
HW Consolidation and Function Virtualization to reduce number of appliances

AS-IS of a Medium size Enel office type



Lower Operation costs due to: Automation, Zero-Touch deployment, less onsite travels, enhanced **Centralized Control** and greater insights.

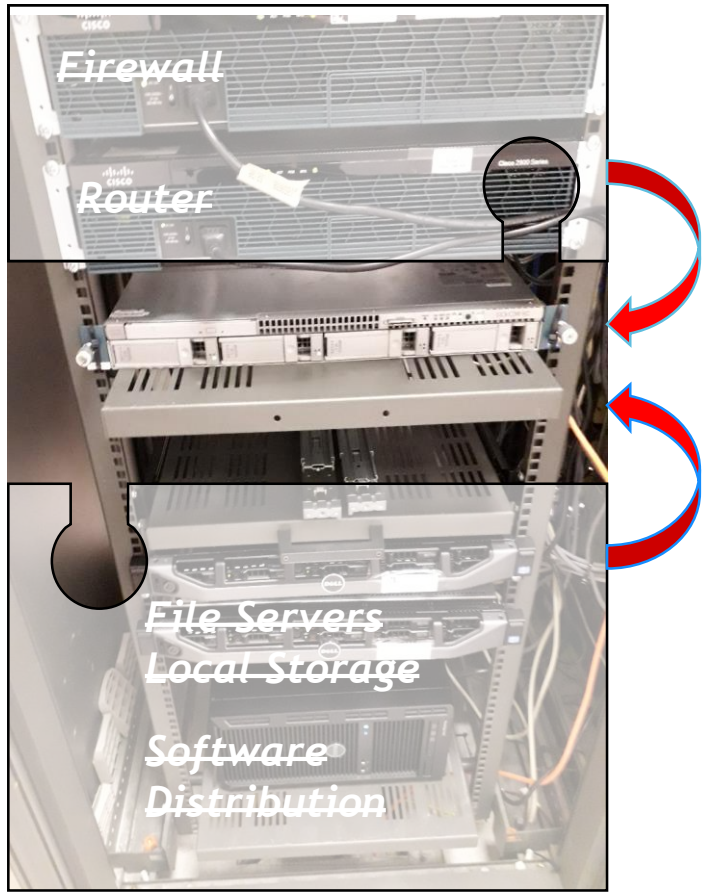
COTS hardware x86 based



Fast Service Provisioning

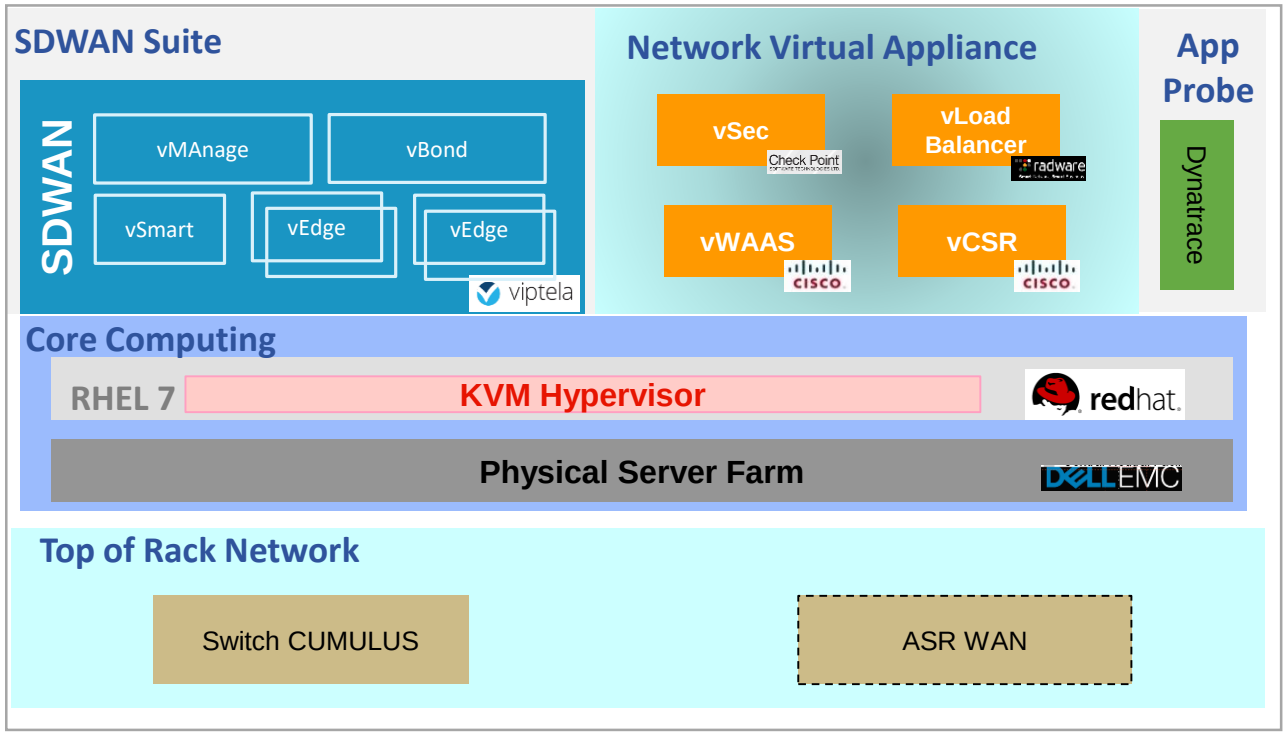
Network functions are **virtually deployed** and centrally managed, reducing service deployment and increasing connectivity flexibility.

TO-BE after virtualization



Network Function Virtualization

Technology framework overview



Framework Overview

 # 7 HOST Dell PowerEdge R640 in FR4

 # 6 HOST Dell PowerEdge R640 in AM3

Virtual Network Functions

- ✓ Viptela Suite
- ✓ Network Appliance

Core Computing

- ✓ RHEL 7 Operating System
- ✓ KVM Hypervisor

Core Network

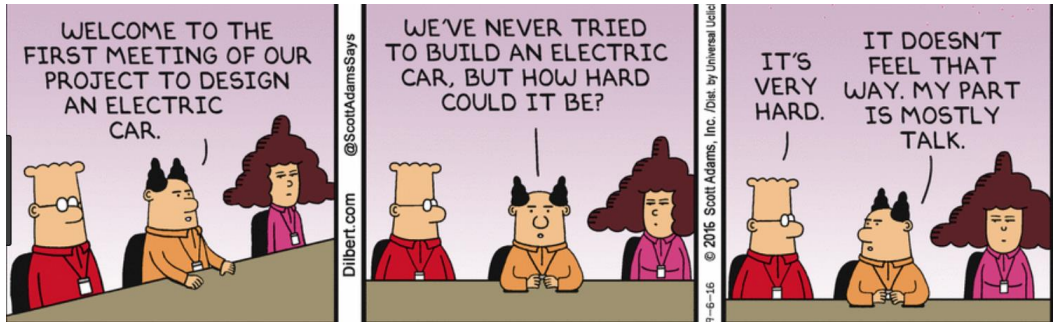
- ✓ Vrouter CSR
- ✓ Switch Cumulus

Beyond Cloud Computing

Learned lessons and graphical information

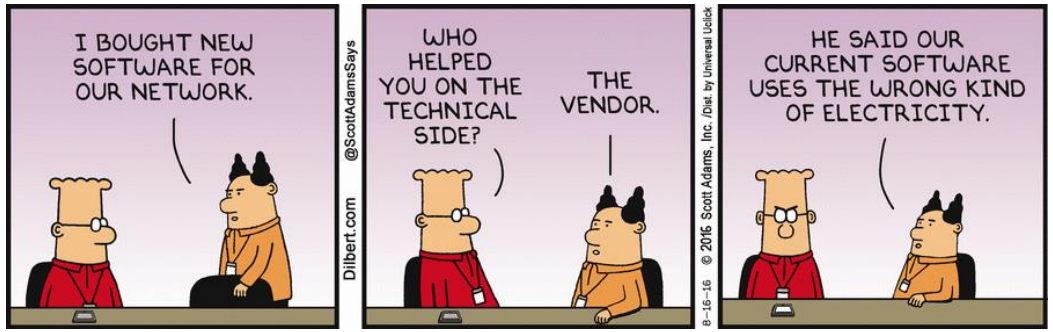
Learned Lessons

1. *Do not underestimate complexity*

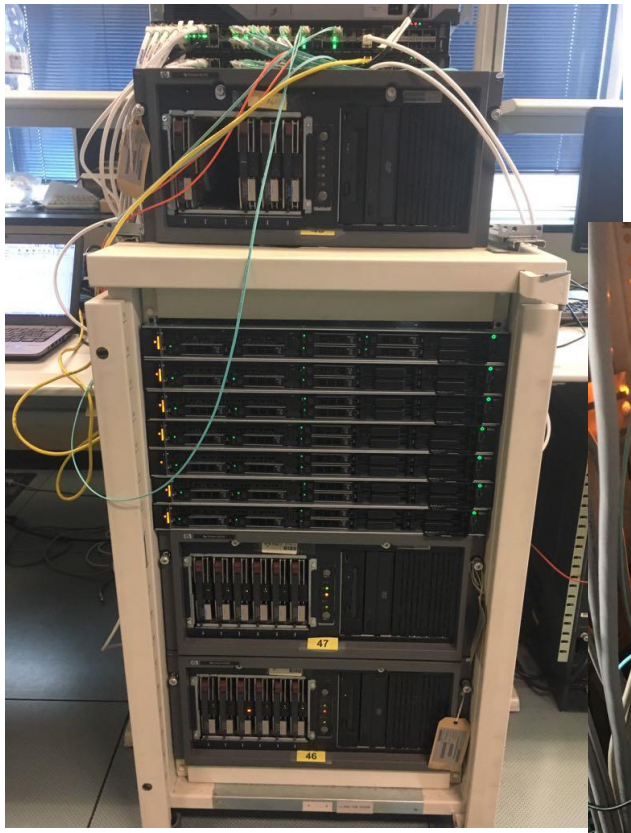


2. *Test environment replica of the real one*

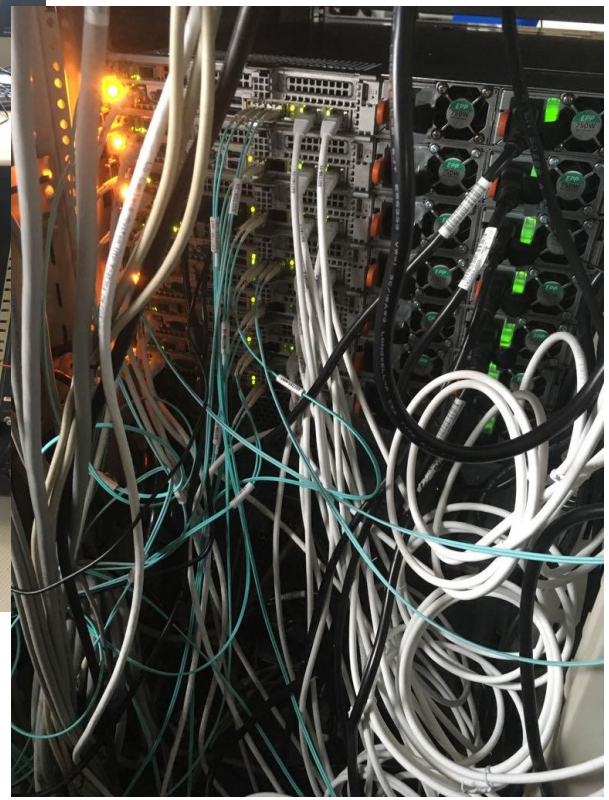
3. *Select skilled resources and partners*



Graphic report: CNF Deployment



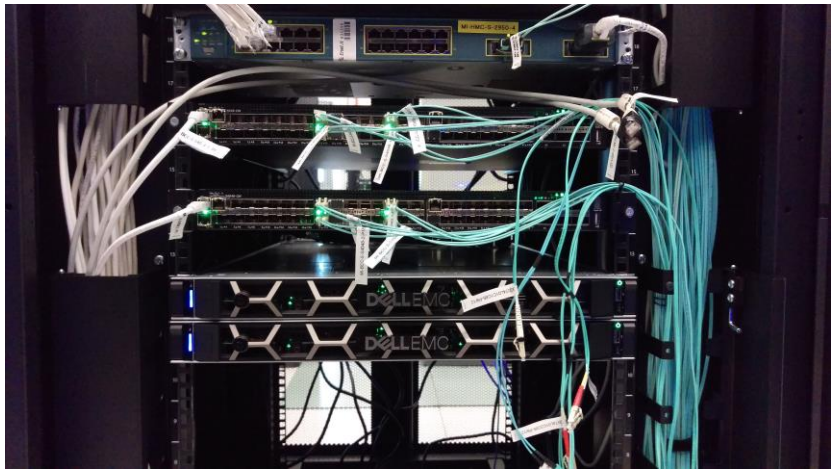
Set up in Milan



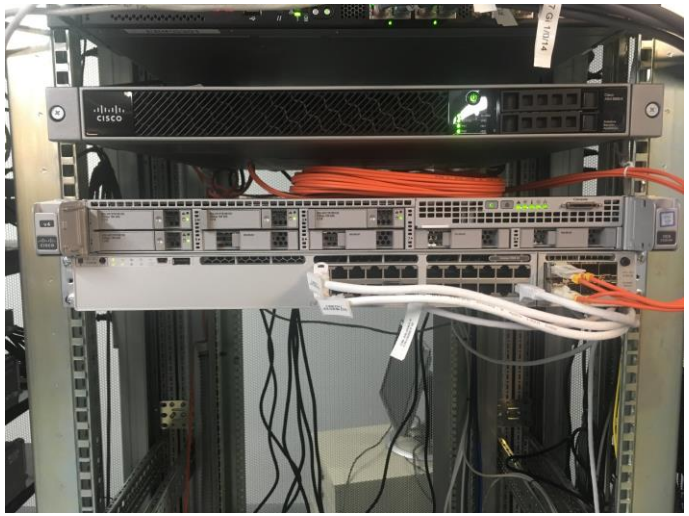
Ready for shipment to FR4

Graphic report: Aggregation Deployment

Goias (CELG)



Rome and Milan



Madrid and Barcelona

Graphic report: Edge Deployment

1st site with 1 CE server
MI Via Barzaghi, 8

1st site with 1 CE whitebox