5G and the Cloud

VITMAC03

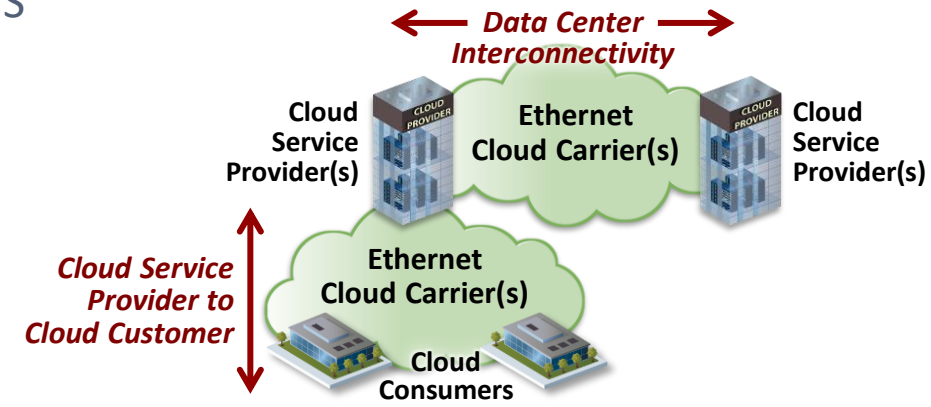
Cloud Networking – the big picture again

Dynamic/automatic/virtualized hardware and networking

- NaaS / IaaS / CaaS / SaaS / PaaS / NFaaS
- Programmability

Hierarchy of data centers

- Mega data centers
- Enterprise-oriented data centers
- Distributed data centers
- Communication data centers
  - Cloud-RAN data centers
  - Traditional local exchange becomes a data center



Growth in Capacity, Users and Connections

- Annual IP traffic is expected to reach a record two zettabytes by 2019, growing at a compound annual rate of 23%.
- The number of Internet users will jump from 39% of the global population in 2014, to 51% in 2019.
- There are expected to be 24 billion connected devices by 2019, or just over three connected devices per user.
- IP video will make up 80% of all global IP traffic by 2019, an increase from 67% in 2014.
- Cellular connections will make up more than 14% of IP traffic in 2019, while WiFi connections will account for 53% globally.

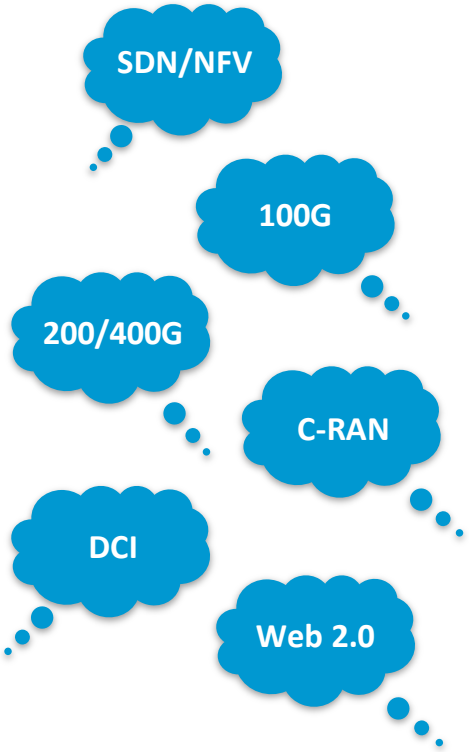
> ***Metro-only traffic*** (traffic that traverses only the metro and bypasses long-haul traffic links) surpasses long-haul traffic in 2014, and will account for 62% of total IP traffic by 2019.

> ***Metro-only traffic will grow nearly twice as fast as long-haul traffic from 2014 to 2019.***

Cisco Visual Networking Index 2015

(Optical Trends)

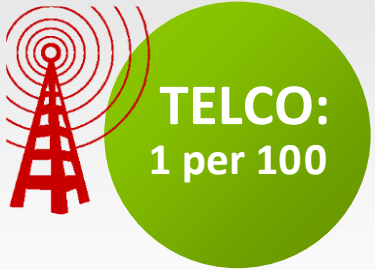
- Optical software revolution – SDN/NFV
  - Programmable optical networking
- Faster adoption of 100G than expected driven by long haul and DCI
- Expected rapid adoption to 200G/400G and beyond
  - More coherent networks
  - Broader range of modulation formats
- New optical networks are being built
  - Mobile (Fronthaul/Cloud-RAN)
  - DCI networks (cloud operators)
- Changing dynamic in the optical industry
  - Web 2.0, mobile…



Motivation: Why SDN/NFV?

Operating Expenses
(Persons per Server)

Google — 1 per 10,000



Time to Revenue

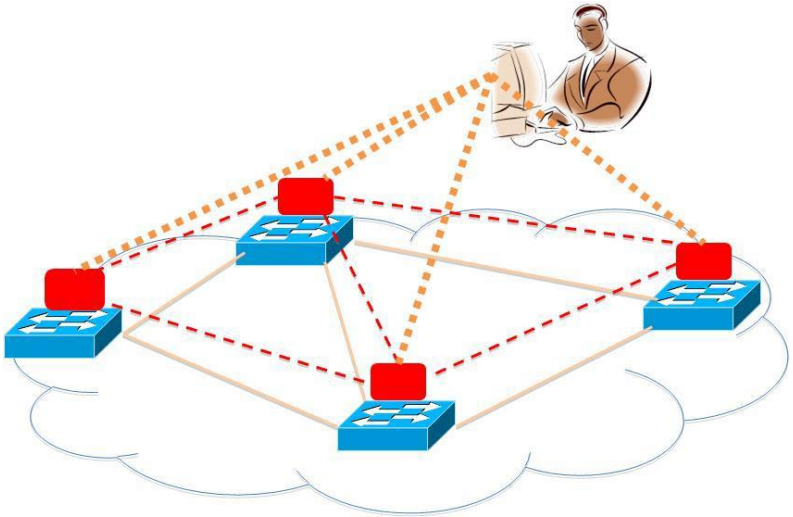
amazon — seconds

Operational Complexity
(Number of Configurations)

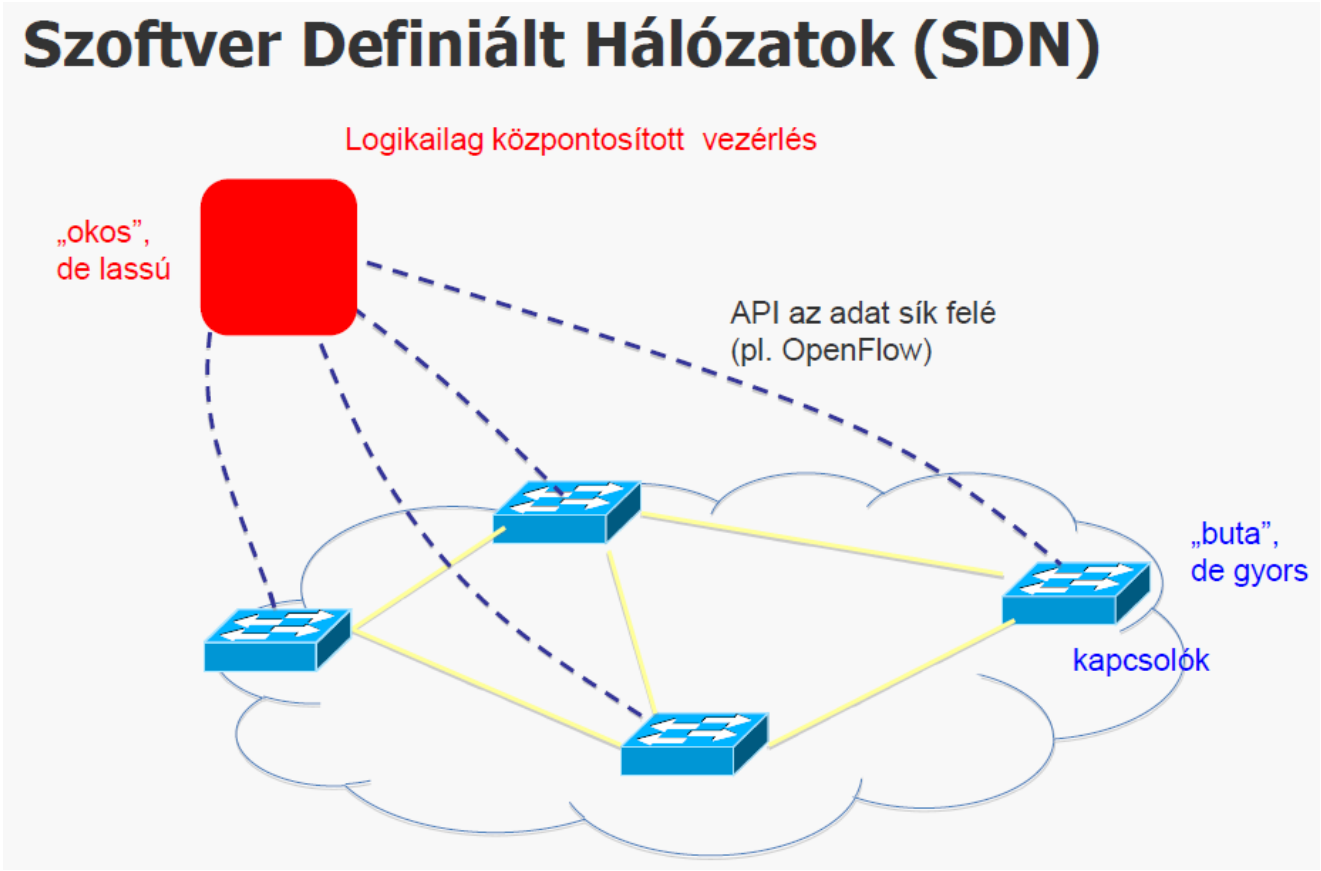
Google — 10 configs

Motivation for SDN – classical network architecture

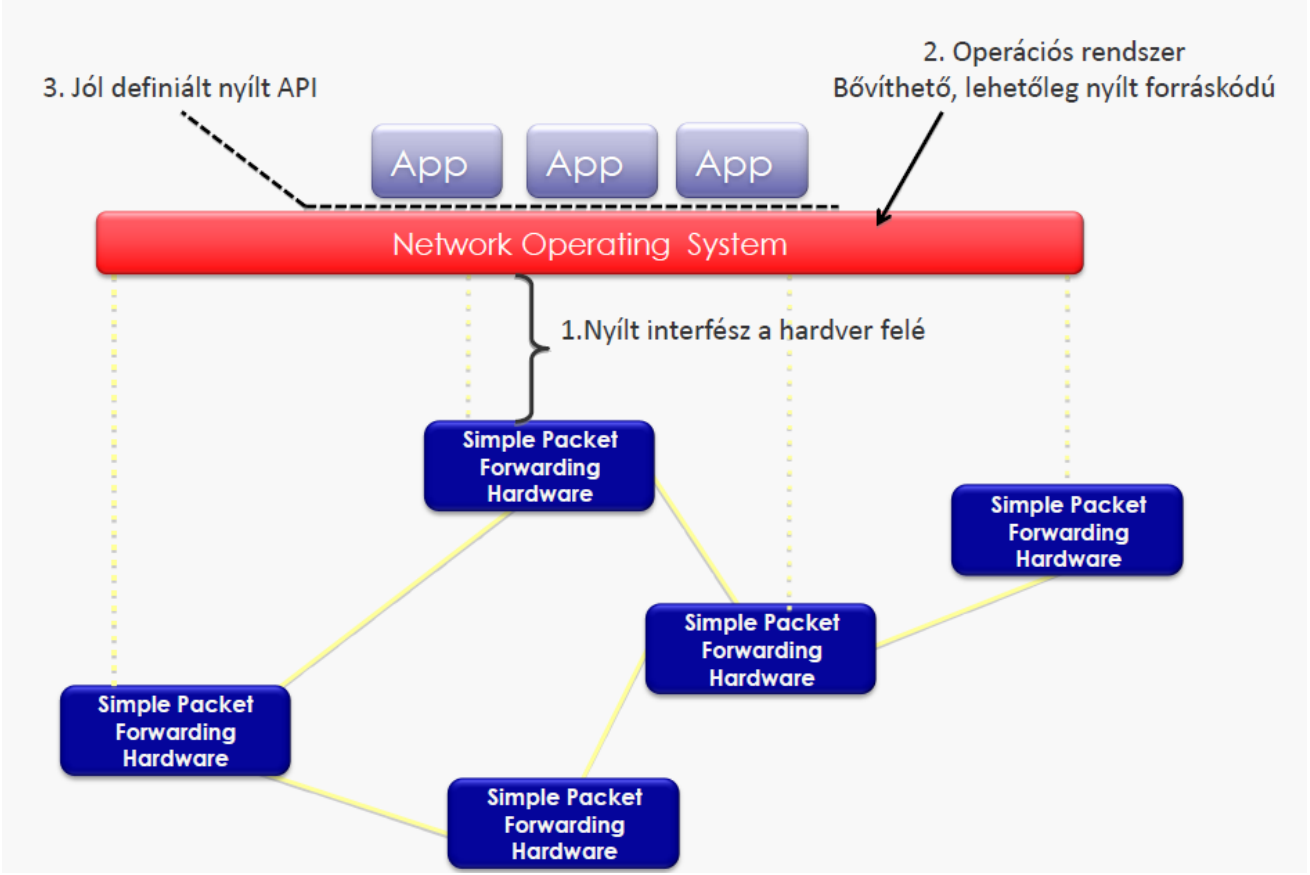
- Adat sík (Data plane): linksebesség időskálán működik (gyors)
  - csomagok kezelése: továbbítás, szűrés, pufferelés, jelölés, ütemezés, számlálók
- Vezérlő sík (Control plane): lassabb időskála (vezérlő üzenetek kezelése)
  - elosztott algoritmusok
  - topológia változósok követése, útvonalak számítása, továbbítási szabályok beállítása
- Menedzsment sík (Management plane): emberi időskála
  - központosított
  - mérések összegyűjtése és eszközök konfigurációja



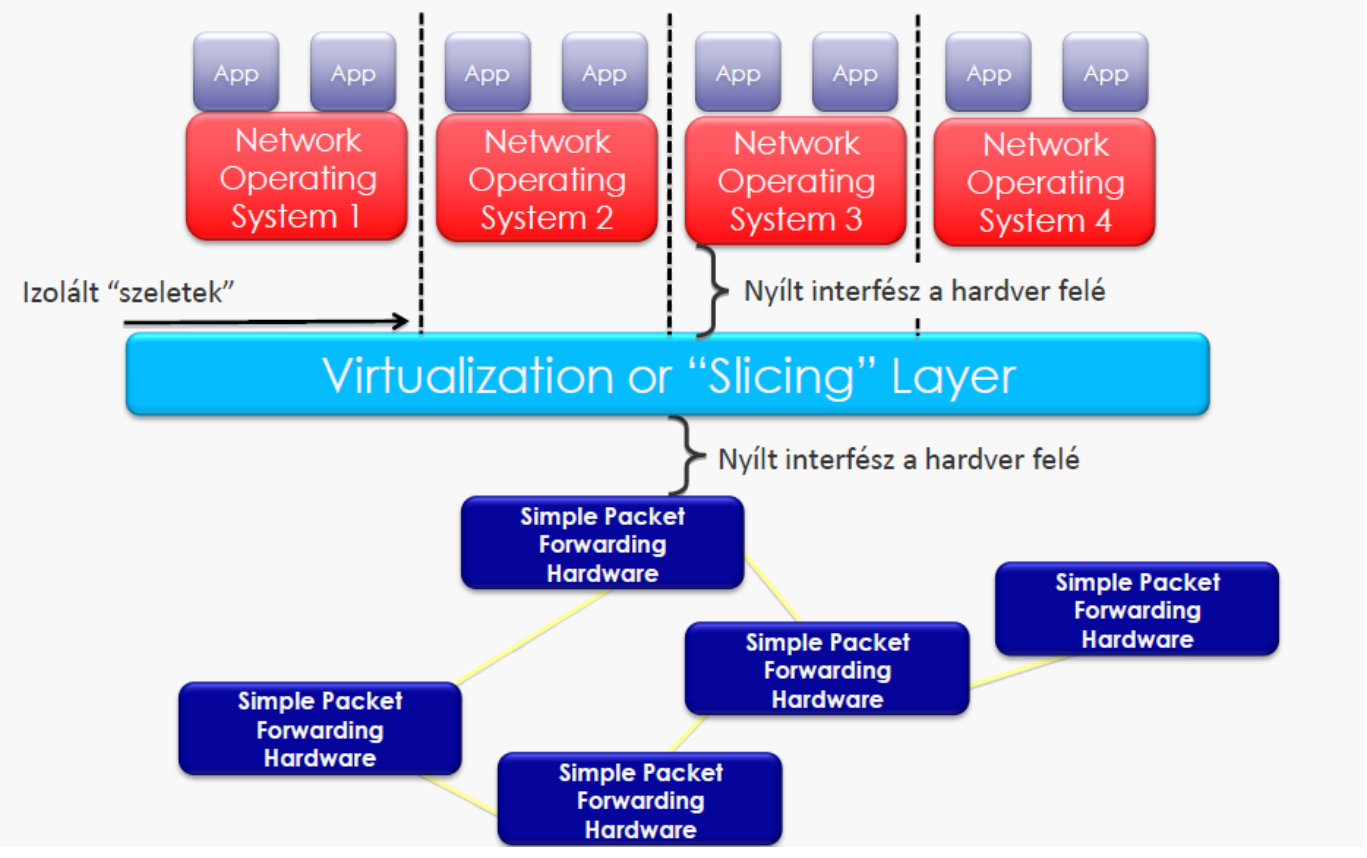
Szoftver Definiált Hálózatok (SDN)



SDN komponensek

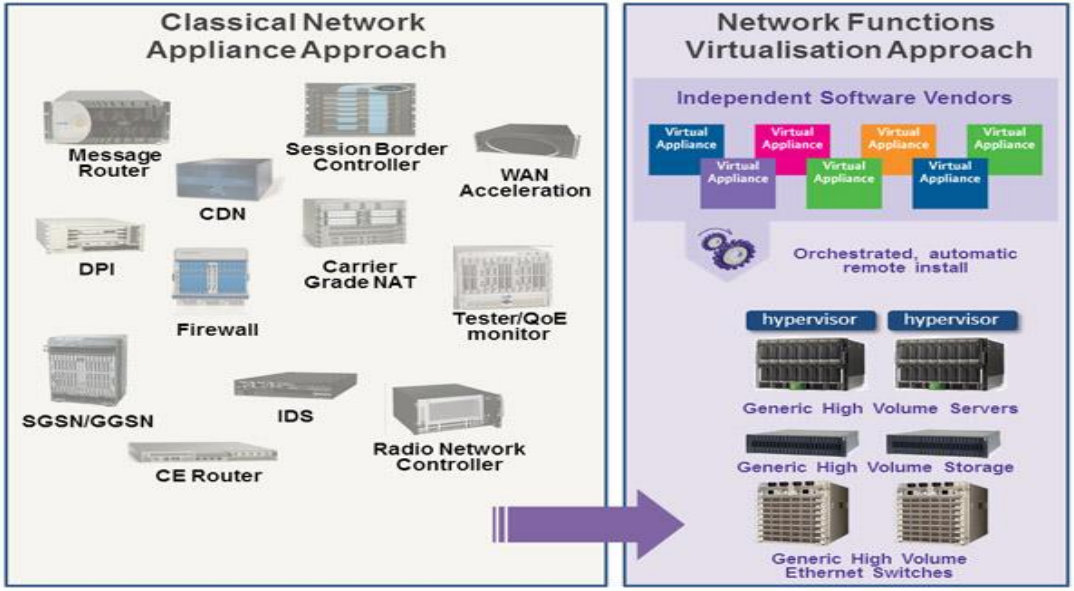


SDN virtualizáció



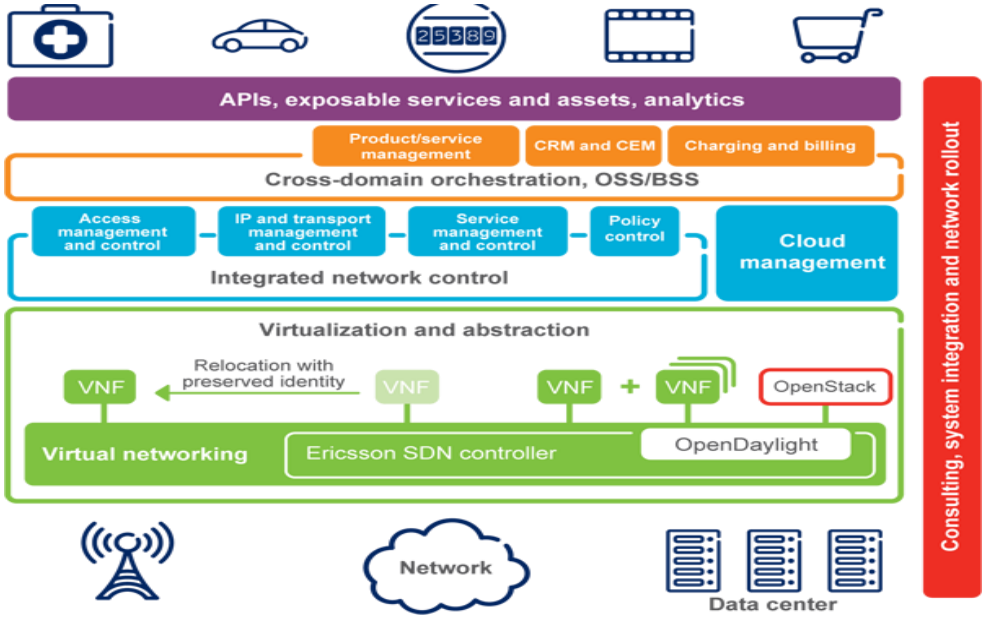
Hálózati funkciók virtualizálása

- Network Functions Virtualization – NFV
  - hálózati funkció (pl. gyorsító-tárazás, tűzfal) leválasztás a célhardver berendezéstől
  - szoftverben megvalósított hálózati funkció
    - tetszőleges általános szerver architektúrán futhat
- Szolgáltatói szempontok
  - CapEx/OpEx költségek csökkentése
  - gyorsabb szolgáltatás létesítés
  - igazodás a változó igényekhez
- Fórumok
  - ETSI NFV
  - Open Platform for NFV (OPNFV)



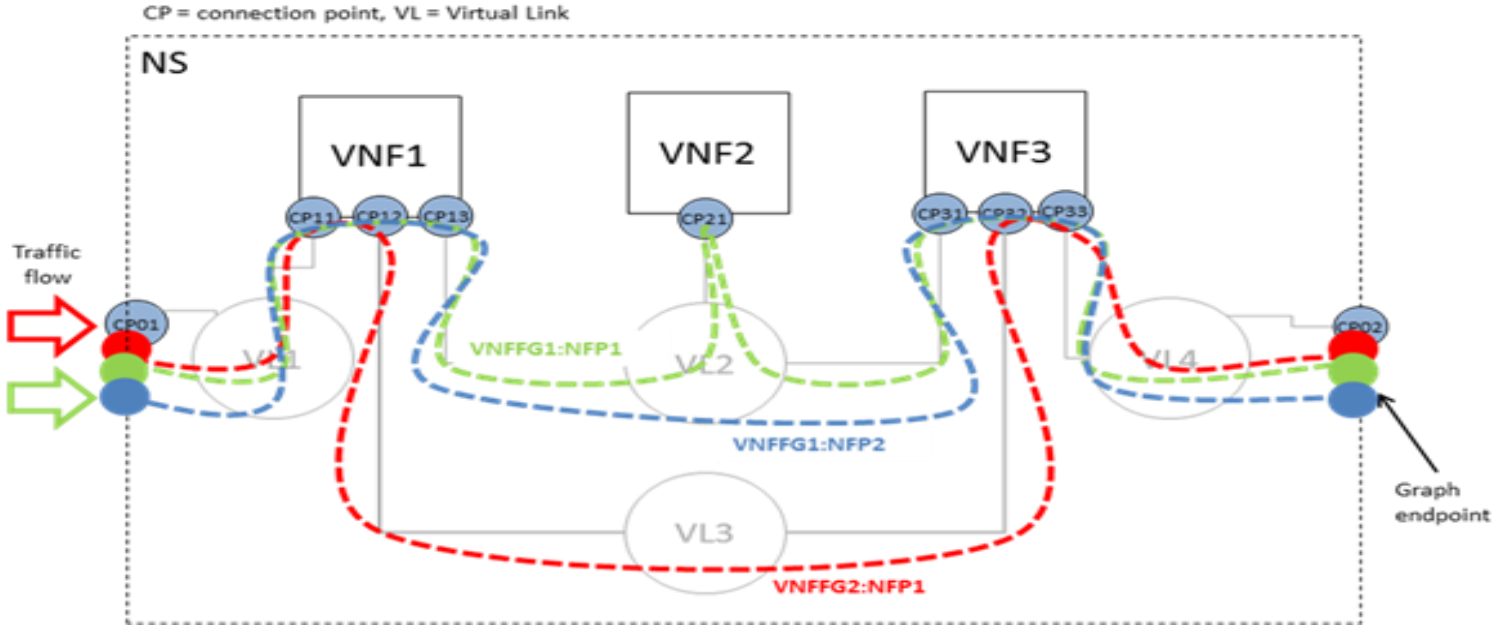
Távközlési felhő

- Virtualizált távközlési funkciók
  - csomagkapcsolt maghálózat (EPC)
  - IMS/VoLTE komponensek (CSCF, HSS, stb.)
  - tartalomszolgáltató hálózat (CDN)
  - csomagtartalom vizsgálat (DPI)
- Teljesítmény
  - terheléskiegyenlítés, skálázhatóság
  - virtuális funkciók közel mozgatása a felhasználási pontokhoz
  - távközlési szintű szolgáltatás
    - létesítés, monitorozás, helyreállítás, számlázás
  - hardveres gyorsítás szükségessége
    - hálózati kártya, virtuális kapcsoló
- Ericsson: valós-idejű távközlési felhő
  - SDN, NFV és felhő kombinációja

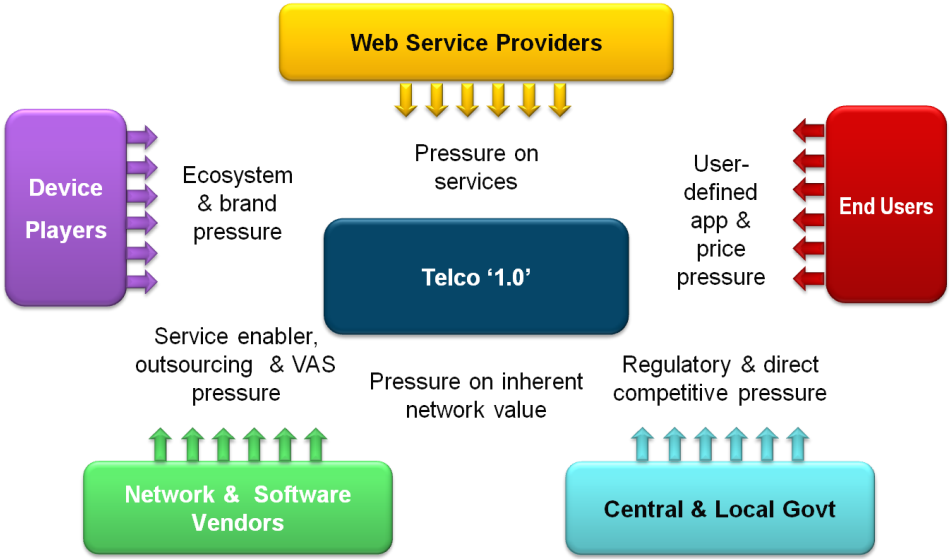


Dinamikus szolgáltatás láncolás

- Egy új szolgáltatás (NS) = VNF-ek összekötése
  - Gráffal lehet leírni



Changing Service Providers' Opportunities



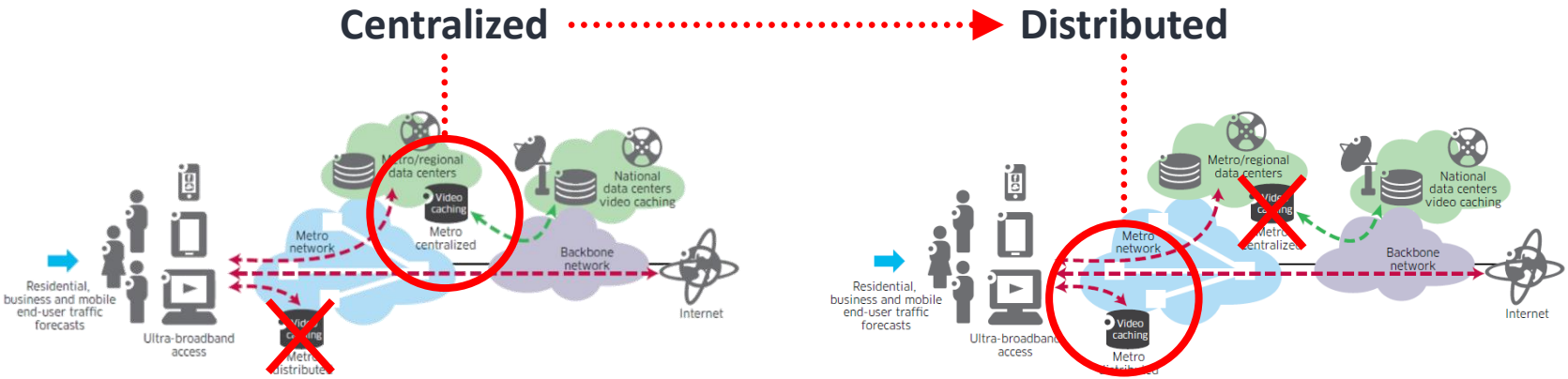
- Business models are changing
- Consolidations in the industry
- Pressure on telecom business model
  - Different business options need to be evaluated

Source: Telco 2.0

Motivation: More traffic stays in the metro

Content closer to the users – distributed metro with distributed cloud

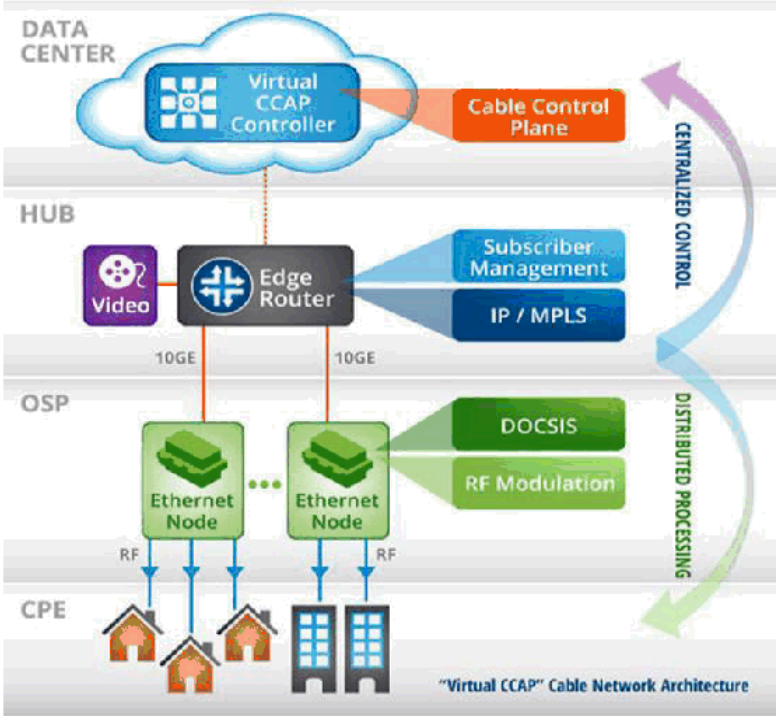
- More local services available
- More bandwidth in the metro



Source: Bell Labs Report

Cable – NGN Remote RF SDN / NFV Controlled Network

- RF modulation moving out – becomes **Fronthaul** like
- DOCSIS processing is moving out
- Shorter cable runs/fiber closer to the customer
- Fewer users per segment/**more bandwidth per user**



Source: Gainspeed

- More 10G Ethernet in the aggregation network
- Video content moving out
- Virtualization of control and communication services

Key wireline standardization issues

- ***Fronthaul*** – Fronthaul ties CRAN to Antennas, major downstream effects.
    - Is it sliced, where, how.
- ***Backhaul/IDC*** – latency, jitter, loss at packet layer, flexible data paths
- ***NFV*** – concept needs to be made broader. Cover some of DSP and all of MEC
- ***MEC*** – ETSI approach ridged. Any F any CPU + RAT (merge into NFV?)
- ***Orchestration*** – does not exist yet. Understand AT&T to build in-house
    - Danger of orchestration/mgmt duplication (virtual/physical)
- ***Softwarization*** – high level programming model, profiles, scripts, end to end
- ***OA&M*** – need “cloud like” approach. Continuous test/repair not just report.

Major Drivers for the 5G wireline architecture

- *End to end virtualization* – obvious operational savings for “tidal” effects
- *Cloud RAN* – opex/capex savings, CoMP, CA, cell edge interference, migration, performance.
- *Mobile Edge Computing* – operators low delay advantage over the OTTs.
- *Fixed Mobile Convergence* – access side also looking for virtualization savings too… can they be combined?
- *Slicing* – differences between RAT’s/CORES etc rather than a one size fits all allows ultra low delay etc. RATS.
- *SDN and Orchestration* – hard to implement all of above with distributed protocols and too complex for manual operation.
- *NFV* – use of general purpose compute as much as possible (but not everywhere) 4G vEPC, 5G-PacketCore$_{[slice]}$, … MEC + some of RAT
- *Better operations/mgmt*, more Cloud-Style, auto problem detect/fix etc.

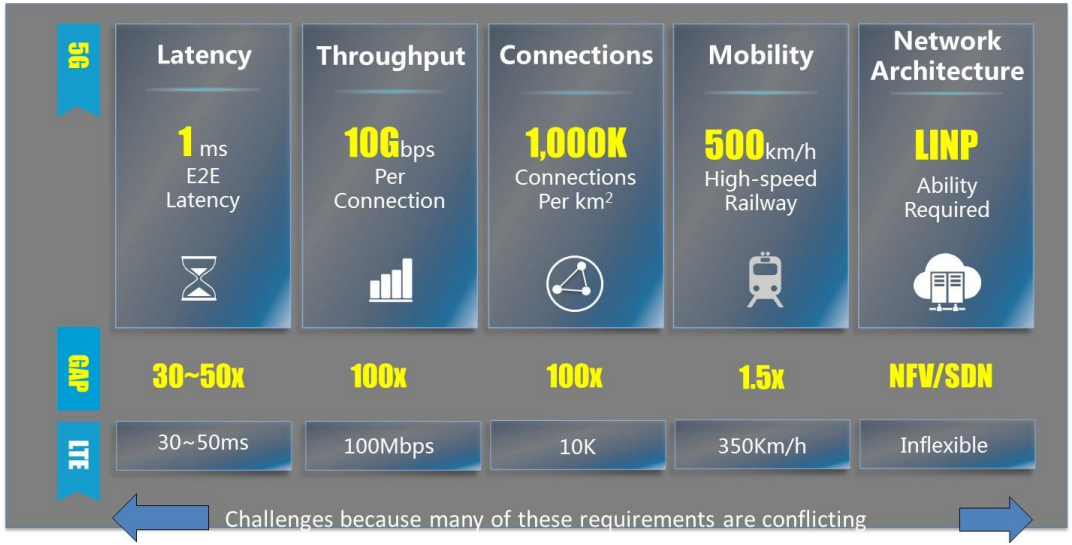
5G: From hardware to software

HW world

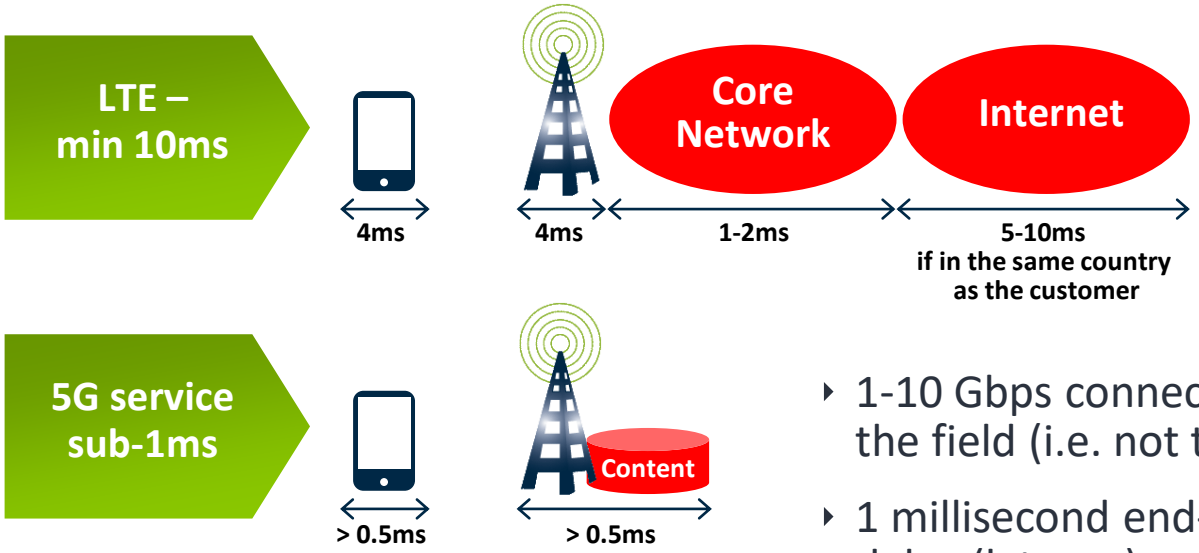
Dedicated appliances +
Dedicated wire/radio

SW world

Virtual functions +
virtual links
on generic server /
storage / network pool



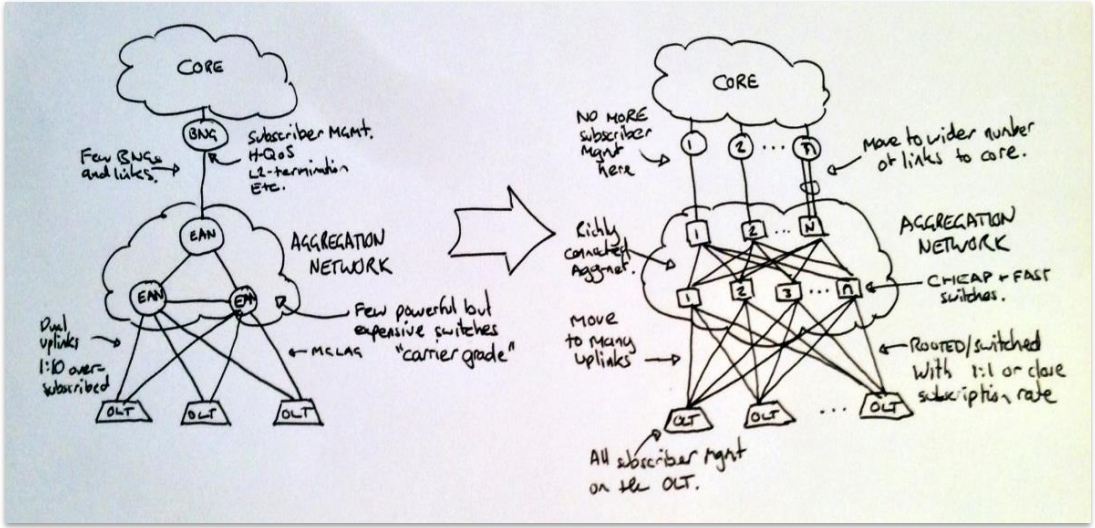
Mobile – 5G Technology Requirements



Source: GSMA

- 1-10 Gbps connections to end points in the field (i.e. not theoretical maximum)
- 1 millisecond end-to-end round trip delay (latency)
- 1000x bandwidth per unit area
- 90% reduction in network energy usage

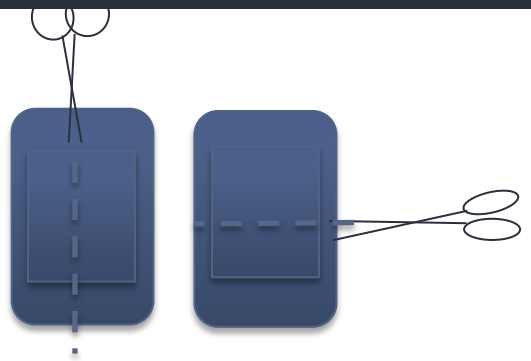
Fixed – What if we move the BNG functions to the OLT?



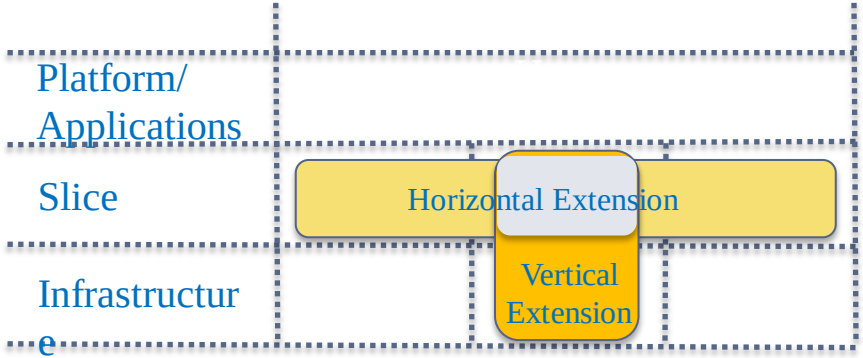
Source: KJP

- Move data plane of subscriber management to a distributed point in the network
- Core and metro aggregation networks becomes closer
- Multiple connections of higher bitrate
- Flattened aggregation network
- Meshier metro aggregation network
- Central office consolidation
- Virtualizing the services

Slicing

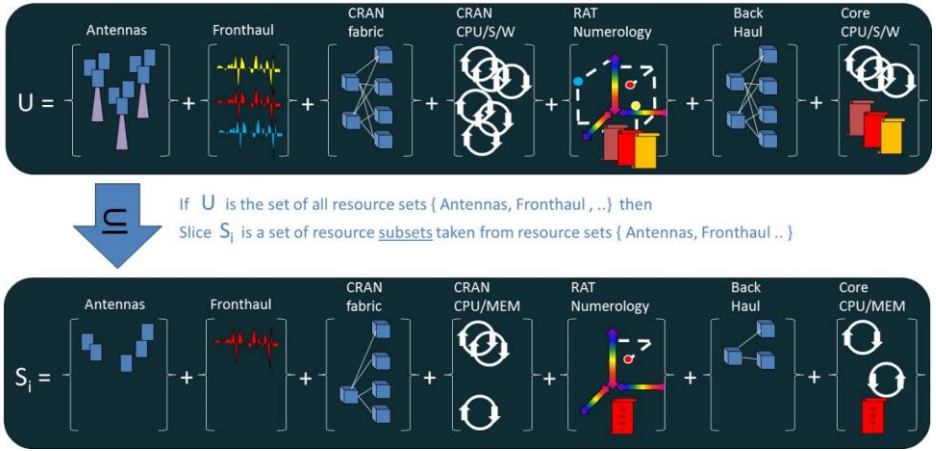


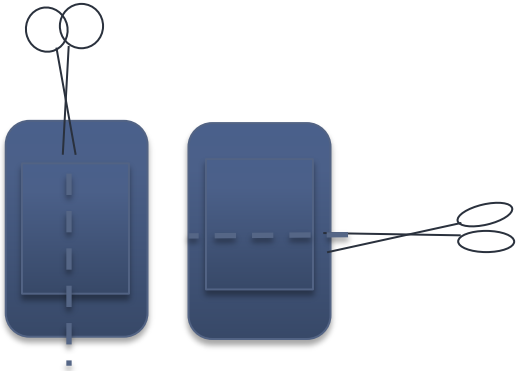
UE-Slicing
Horizontal or
Vertical



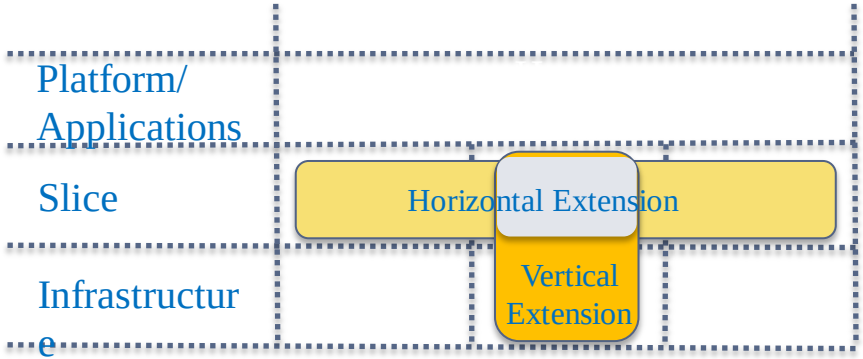
Example:
5G concept of end to

end slice

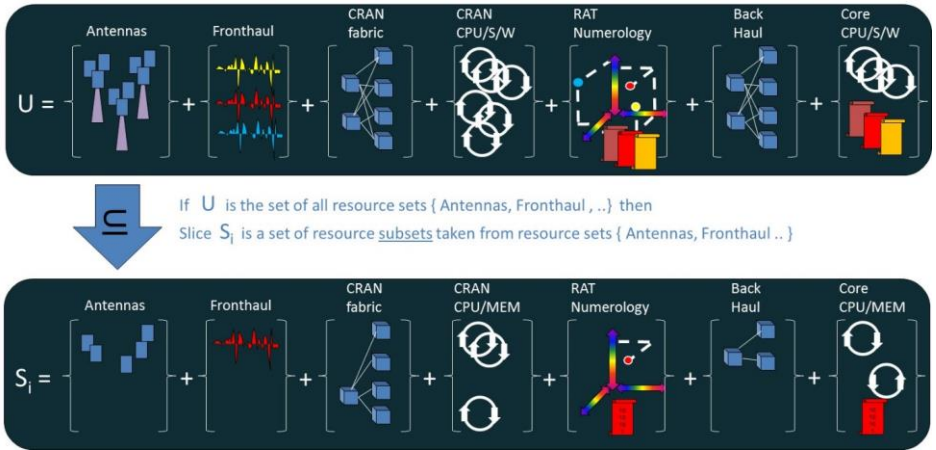




UE-Slicing
Horizontal or
Vertical



Example: 5G concept of end to end slice



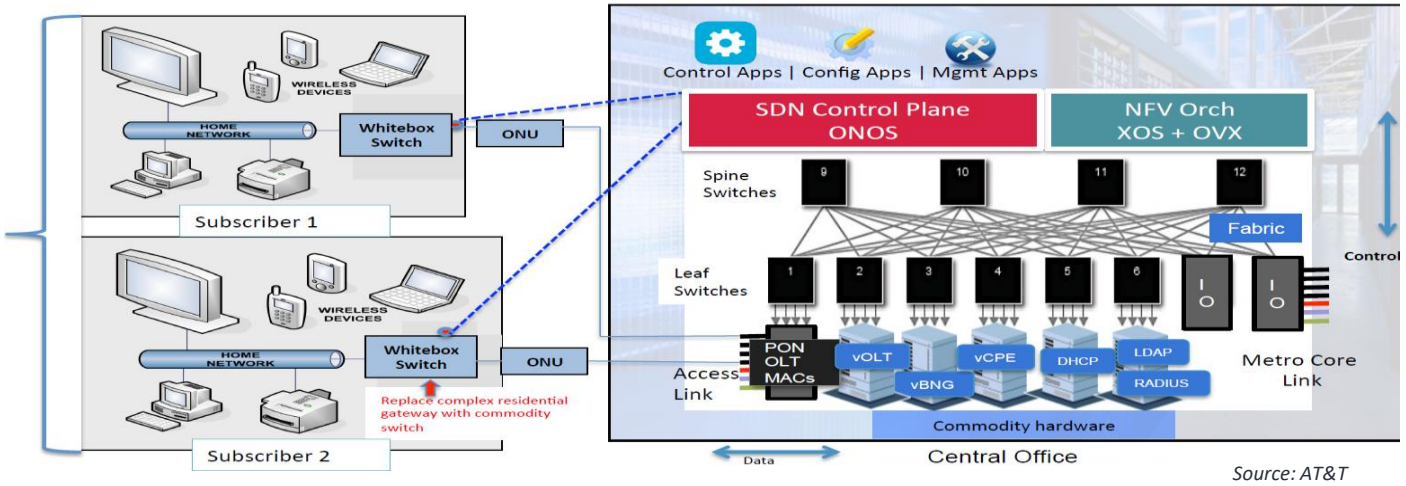
Central Office goes Data Center

vCPE

- CPE replaced with a simple switch
- Functionality that existed on CPE virtualized and moved into the Central Office

vOLT

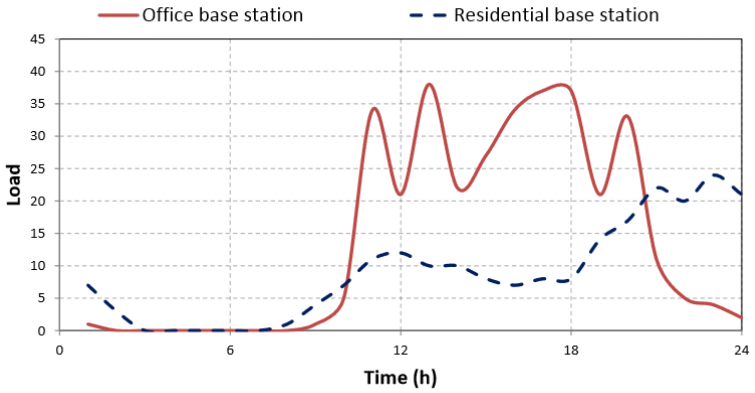
- Everything but the MCs can be virtualized
- And moved to NFVI running over standard:
  - Fabric Switches
  - Storage
  - Servers

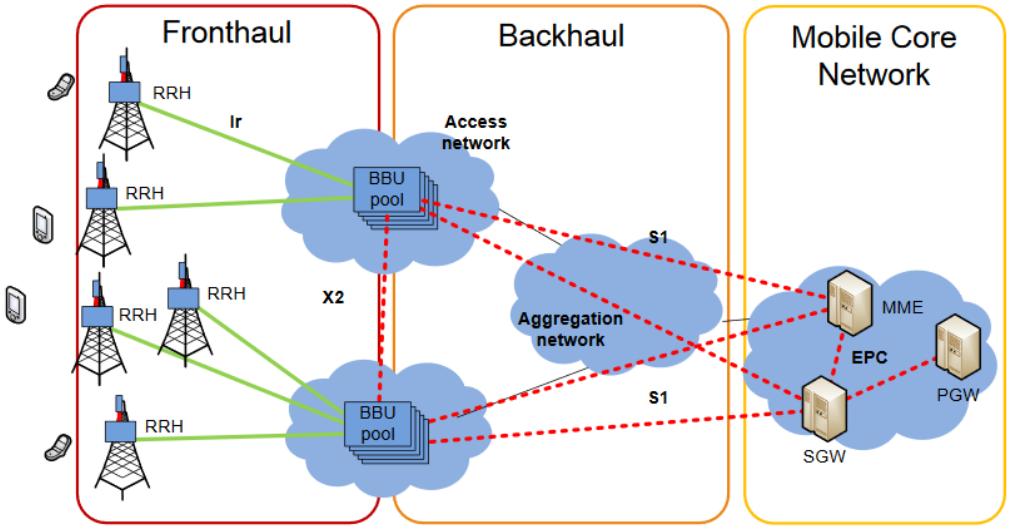


Source: AT&T

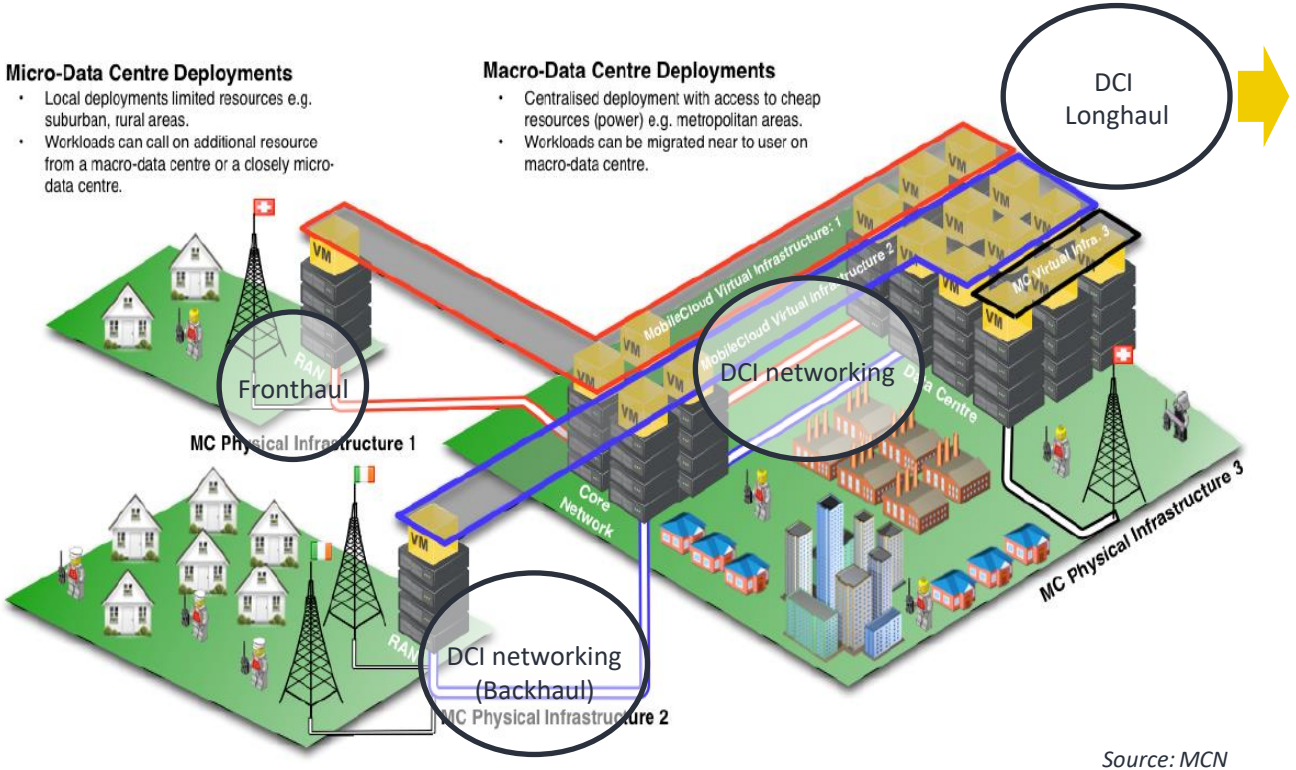
Cloud RAN

- Goal: optimize BBU utilization between heavily and lightly loaded base stations





Macro to Micro Data Centers for MobileCloud



Source: MCN

NFaaS (Network Function as a Service)

- Simplified architecture
  - Specialized middle boxes are replaced with common hardware i.e. uniform infrastructure
- Reduced CapEx
  - Specialized components are replaced by common hardware and open source software
- Decreased OpEx
  - Through automation
- Flexibility
  - Through infrastructure virtualization and the ability to manage functions at the service level