NFV and SDN: The enablers for elastic networks

Kashif Mahmood,
Next Generation Network Technology (NGNT) Group, Telenor Research, Norway

UNIK Guest Lecture, 8th May 2014

telenor group

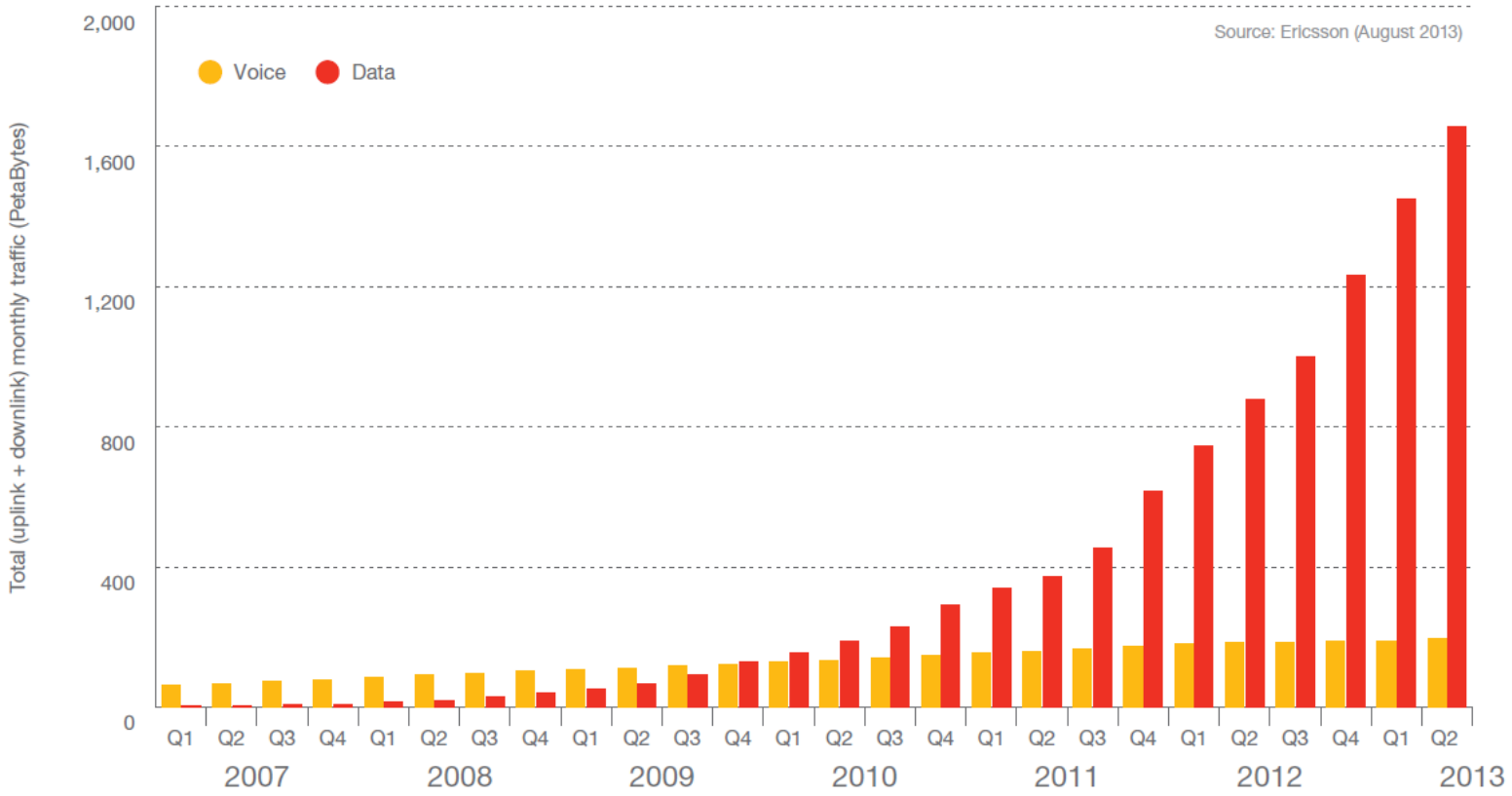
Outline

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

Outline

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

Challenges: Video dominated exponential data growth



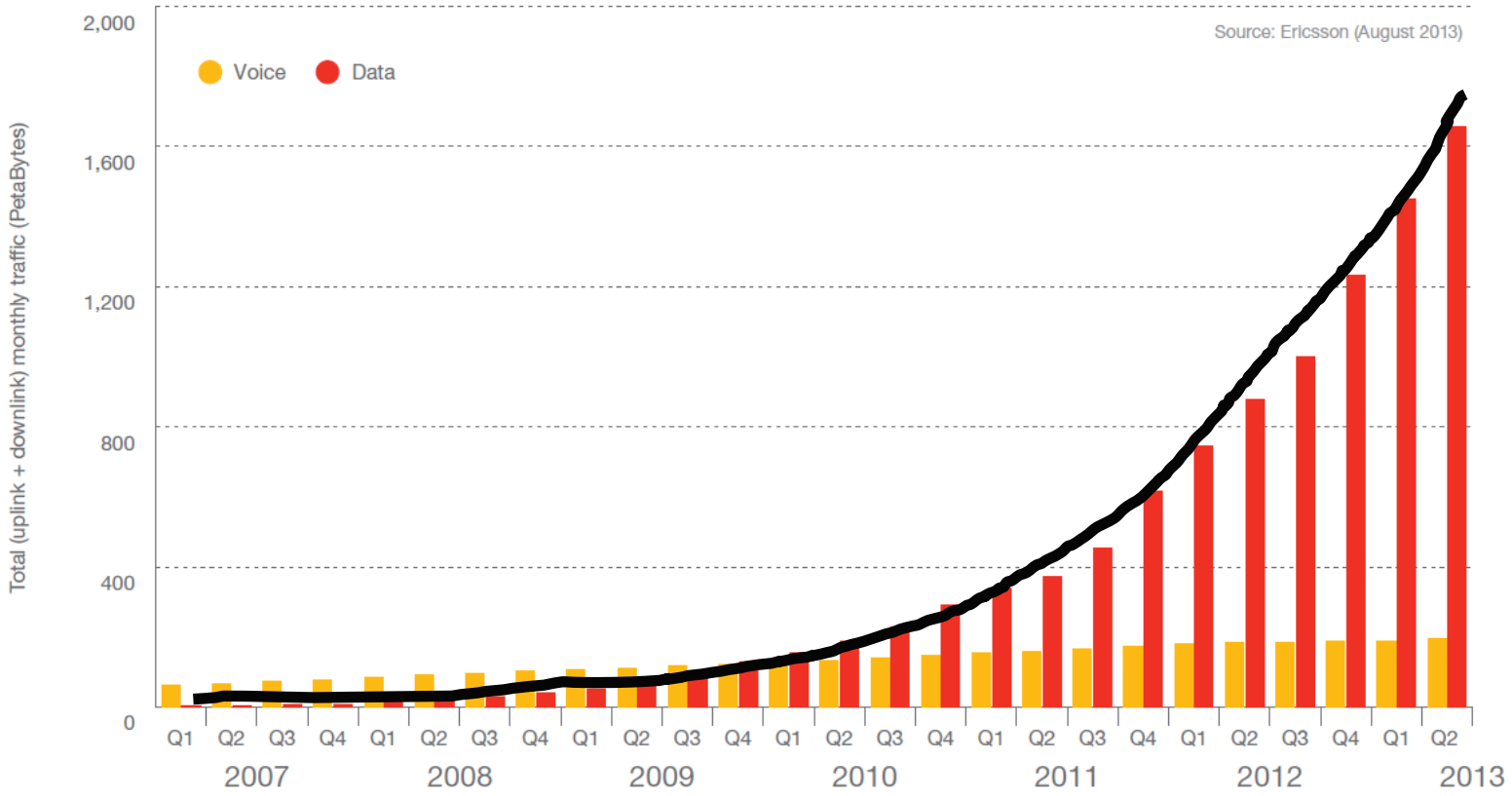
*Source : Ericson mobility report

- Voice to data

*Traffic does not include DVB-H, Wi-Fi, or Mobile WiMax. Voice does not include VoIP.

telenor group

Challenges: Video dominated exponential data growth



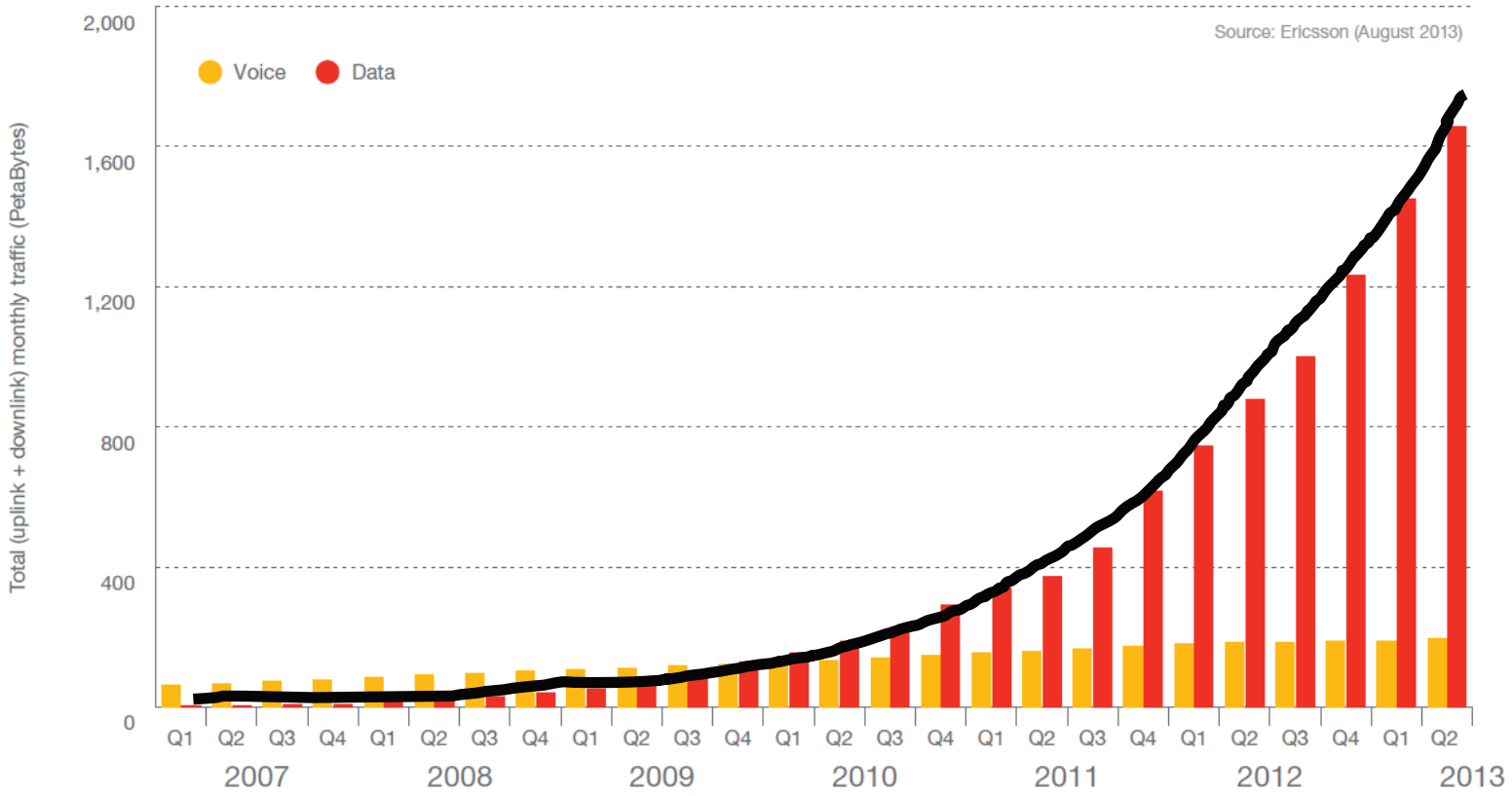
*Source : Ericson mobility report

- Voice to data
- Exponential data growth

*Traffic does not include DVB-H, Wi-Fi, or Mobile WiMax. Voice does not include VoIP.

telenor group

Challenges: Video dominated exponential data growth



*Source : Ericson mobility report

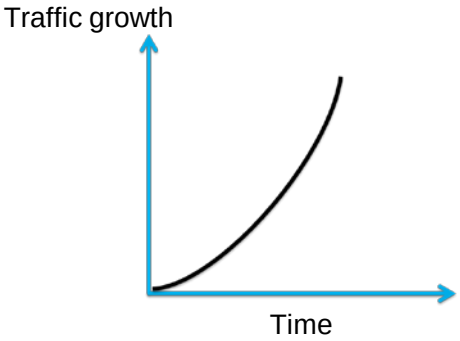
- Voice to data
- Exponential data growth
- Mobile video traffic → 69% of data traffic by the end of 2018 ~CVI
  - Roughly a quarter of Netflix subscribers already streaming video to their smartphones, ~RCR Wireless

*Traffic does not include DVB-H, Wi-Fi, or Mobile WiMax. Voice does not include VoIP.

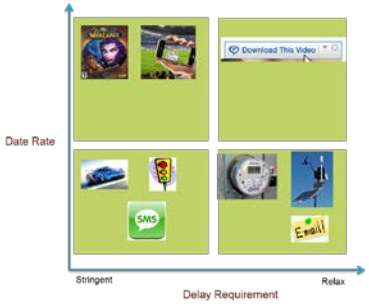
telenor group

Challenges:

- Video dominated exponential data growth

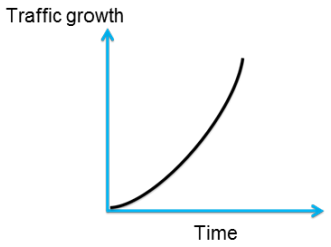


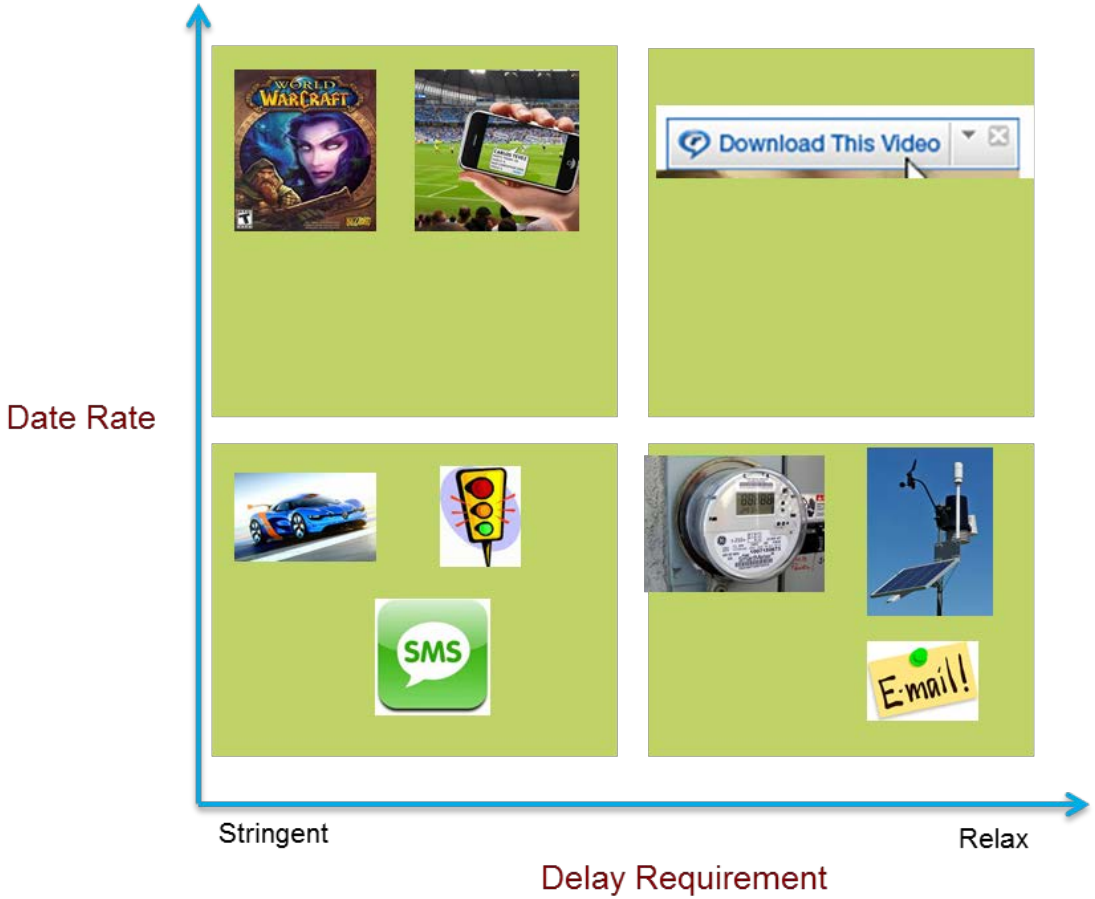
- Diverse traffic



telenor group

Challenges: Diverse traffic

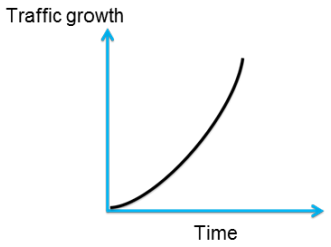


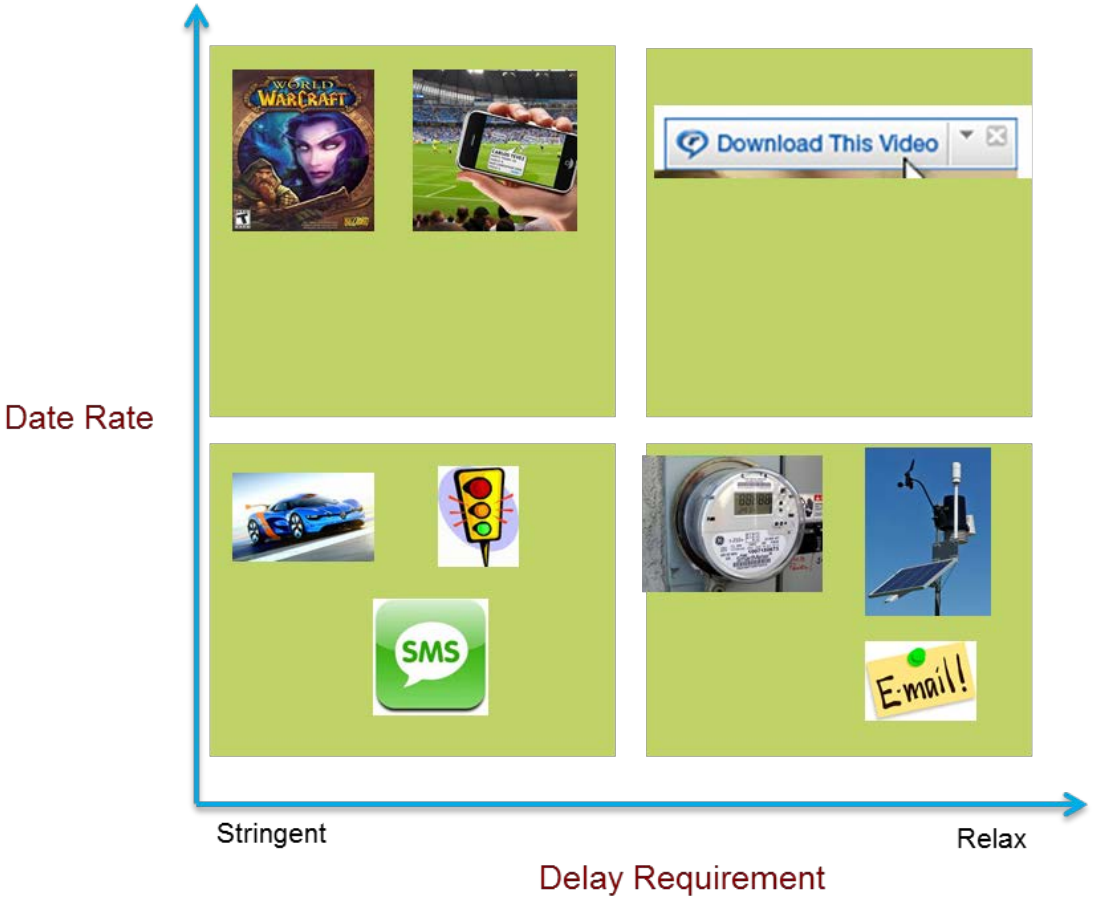


- Traffic type : Emergency services, Machine to Machine, IoT …
  - Signaling storm → “Always on” nature of mobile networks

telenor group

Challenges: Diverse traffic



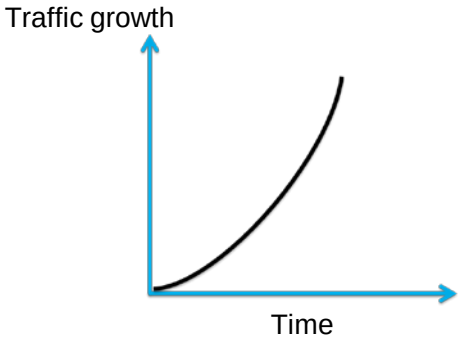


- Traffic type : Emergency services, Machine to Machine, IoT …
  - Signaling storm → “Always on” nature of mobile networks

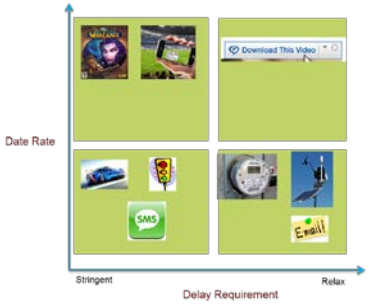
telenor group

Challenges:

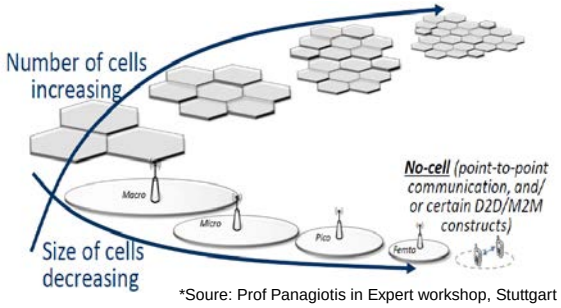
- Video dominated exponential data growth



- Diverse traffic



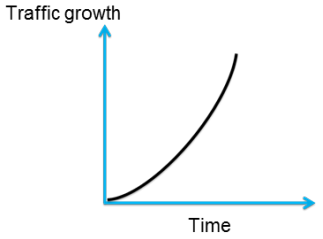
- Ultra dense heterogeneous networks

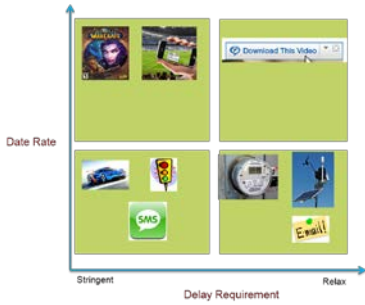


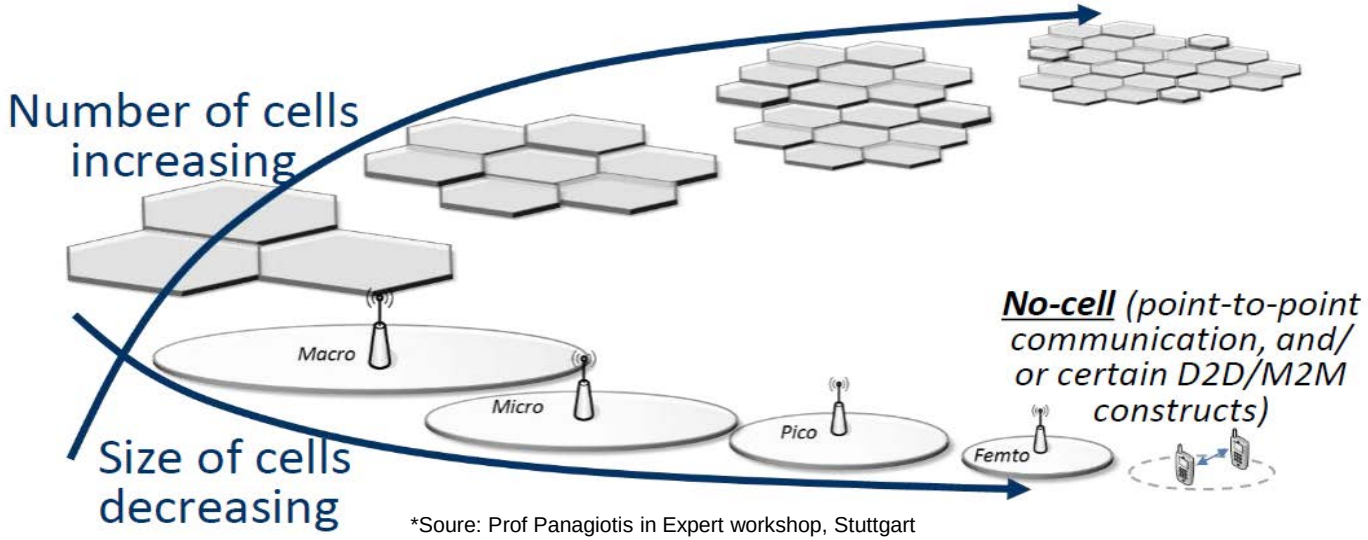
*Soure: Prof Panagiotis in Expert workshop, Stuttgart

telenor group

Challenges: Ultra dense heterogeneous networks







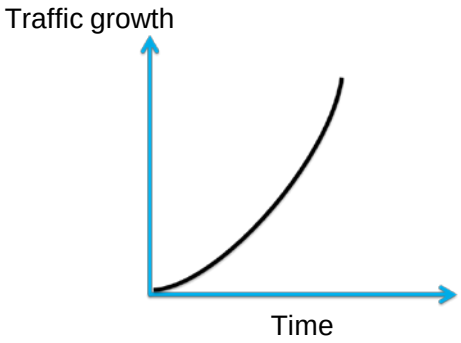
*Soure: Prof Panagiotis in Expert workshop, Stuttgart

- 3-10 or more small cells per macro cells
- cells shrinking (from macro to no cell concept)

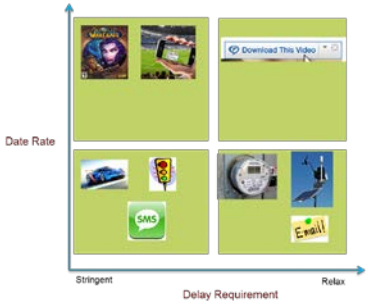
telenor group

Challenges:

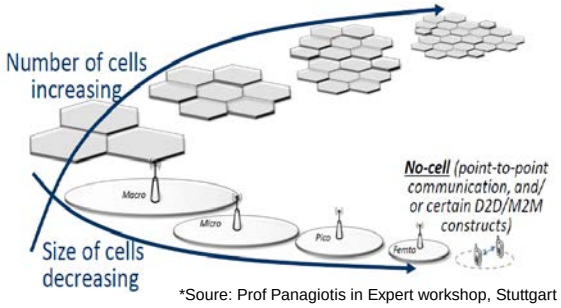
- Video dominated exponential data growth



- Diverse traffic



- Ultra dense heterogeneous networks



*Soure: Prof Panagiotis in Expert workshop, Stuttgart

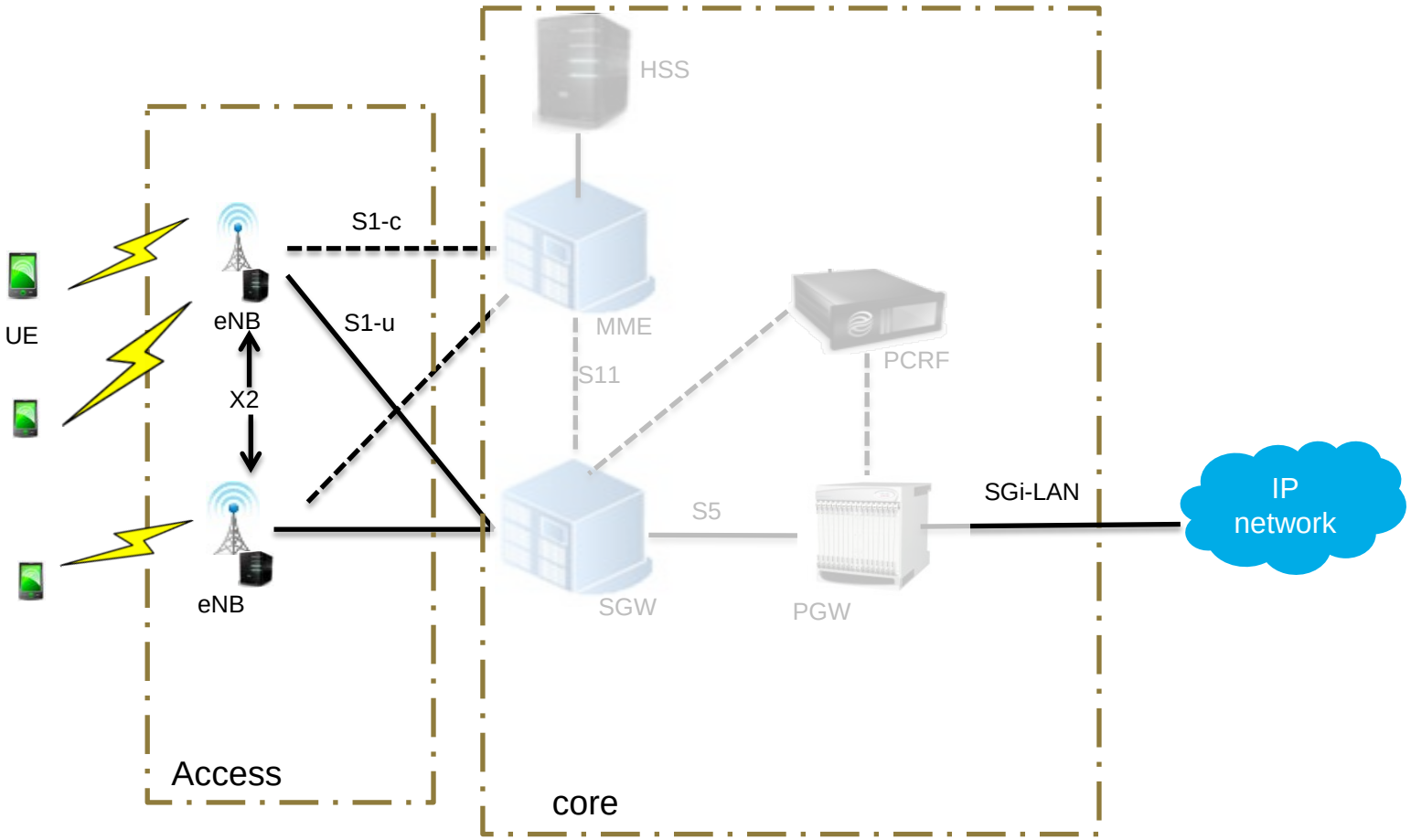
- No more competition on the basis of network coverage but on the basis of features and services.

telenor group

Outline

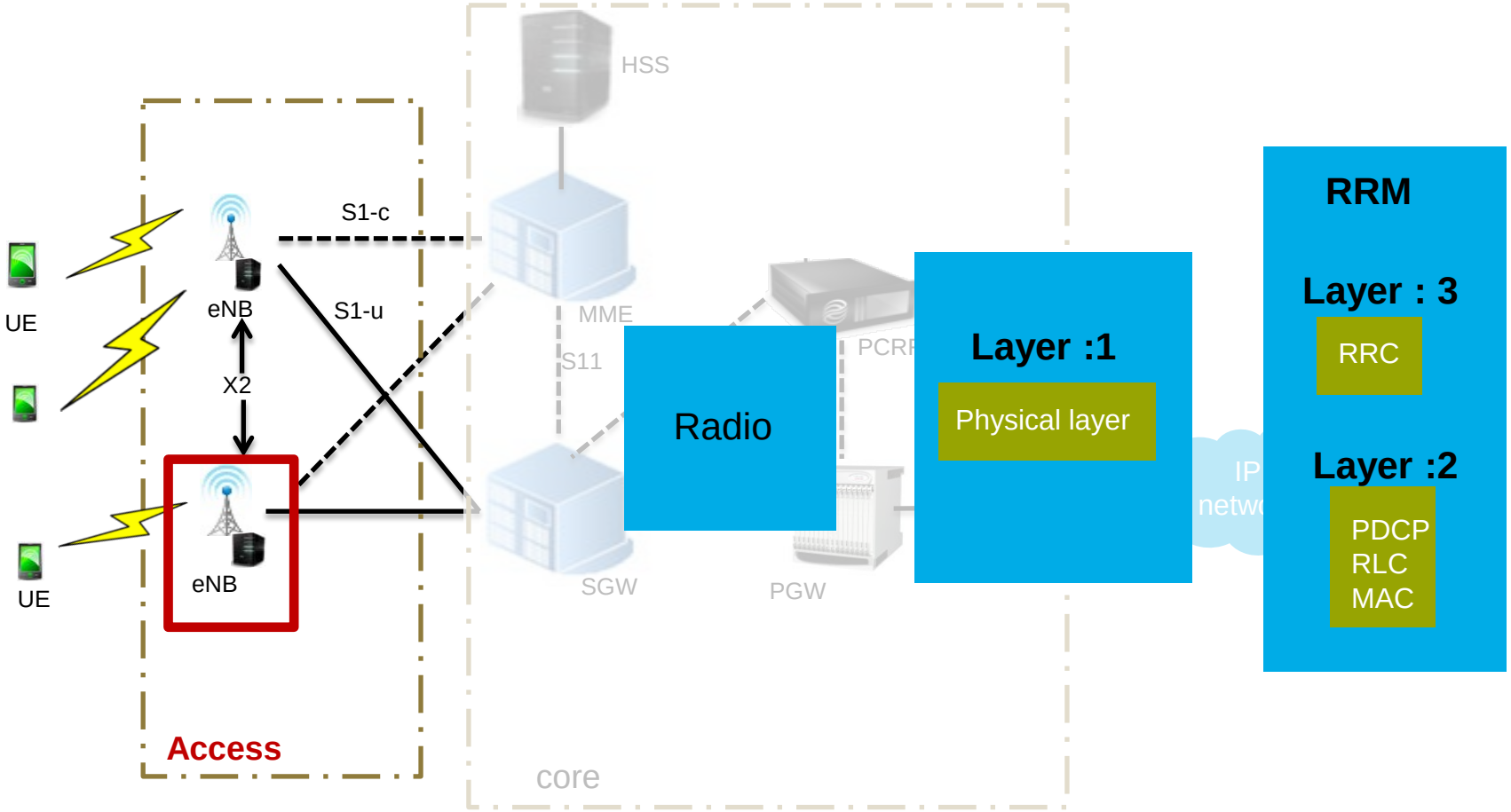
- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

The Network of today



telenor group

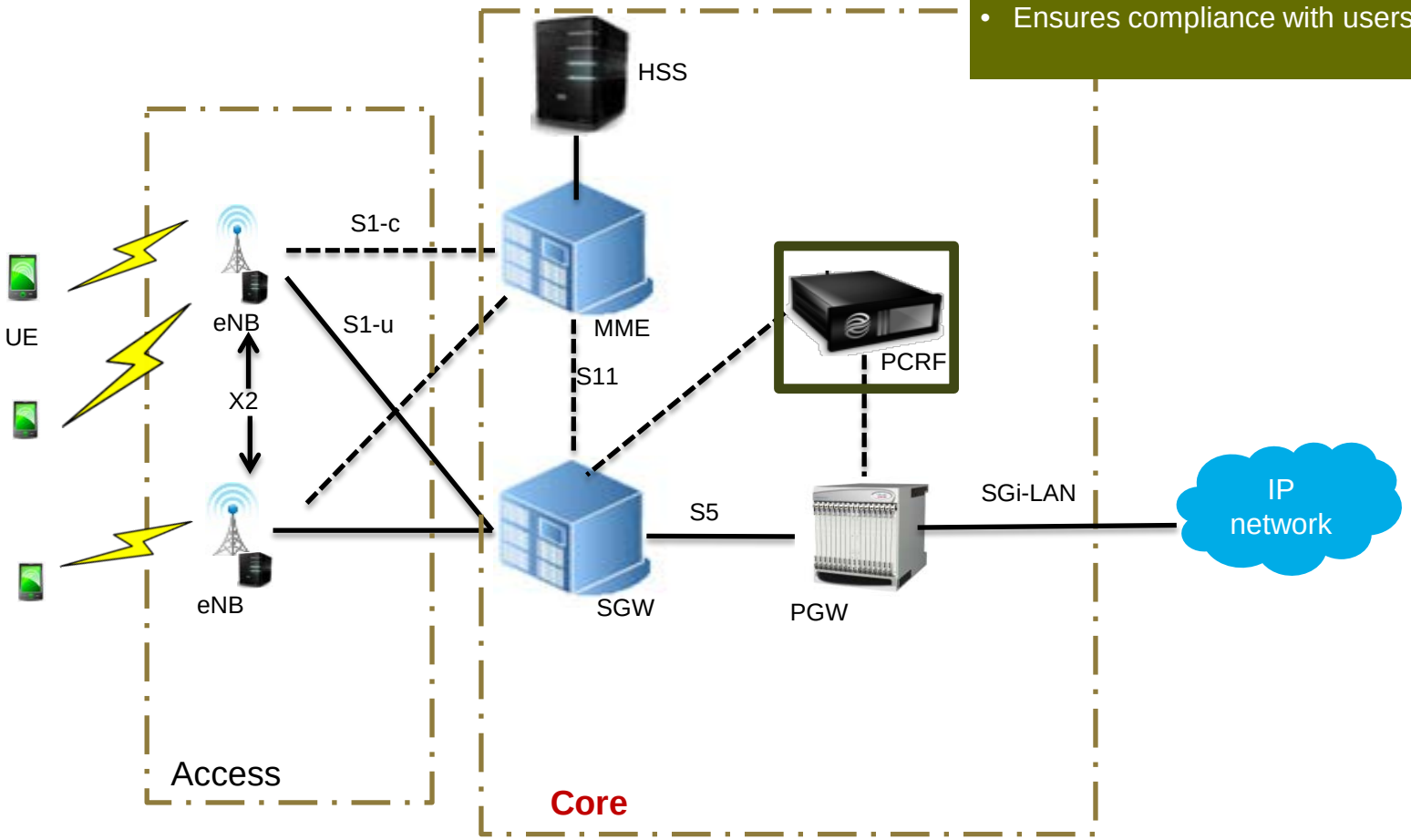
The Network of today



telenor group

The Network of today

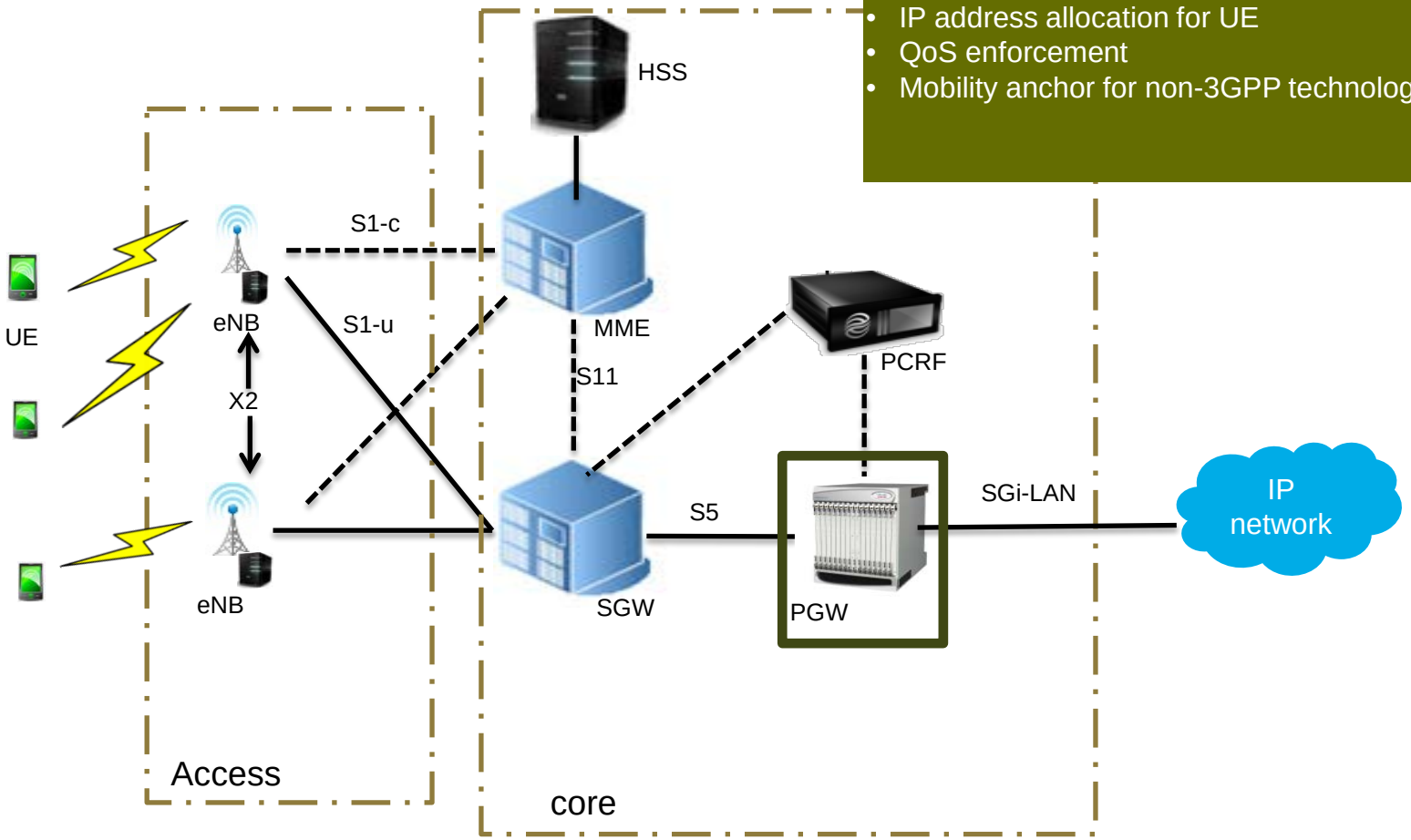
- Controls flow-based charging functionalities in PGW
- Ensures compliance with users subscription



telenor group

The Network of today

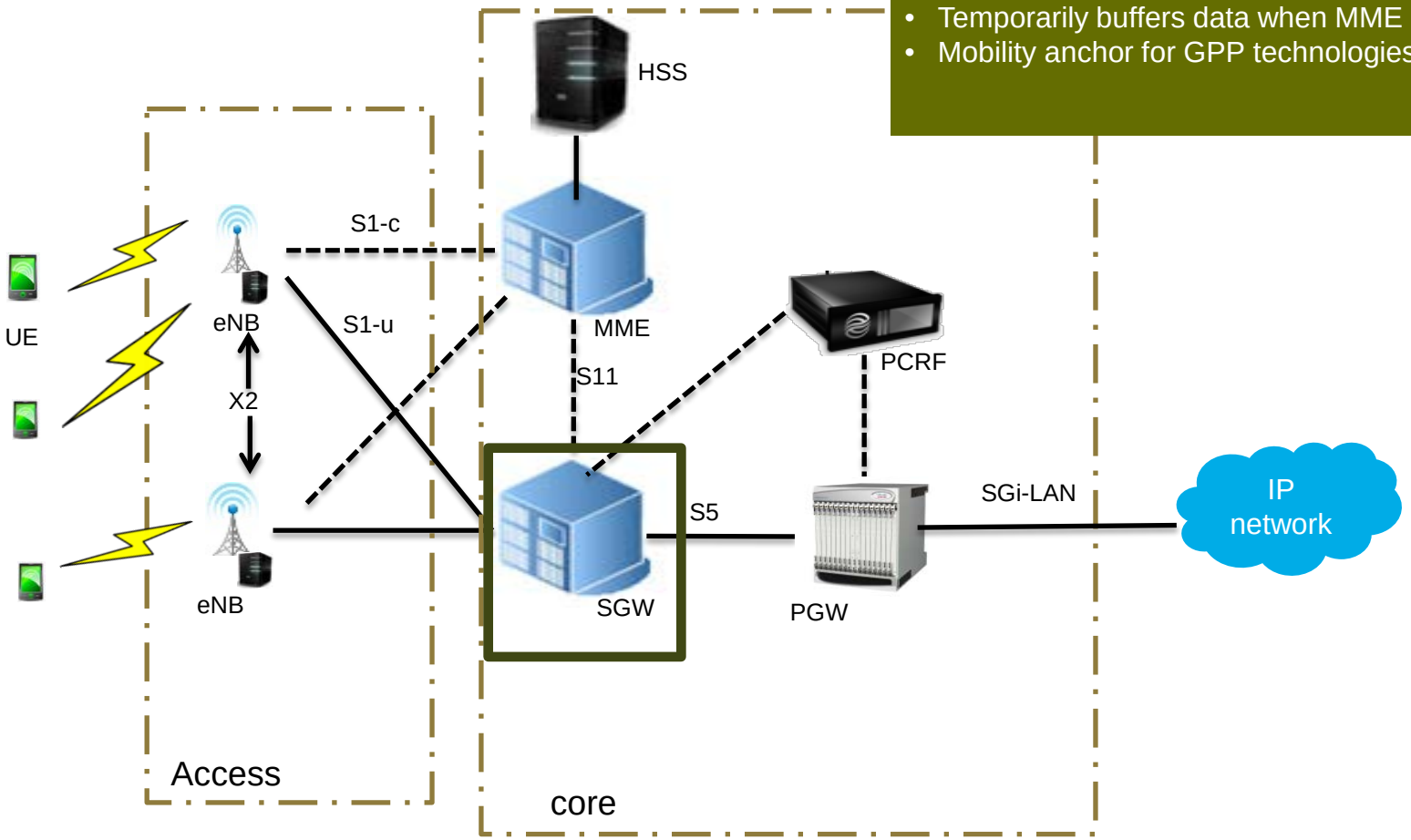
- UL and DL service level charging (input from PCRF, DPI)
- IP address allocation for UE
- QoS enforcement
- Mobility anchor for non-3GPP technologies (CDMA, WiMAX)



telenor group

The Network of today

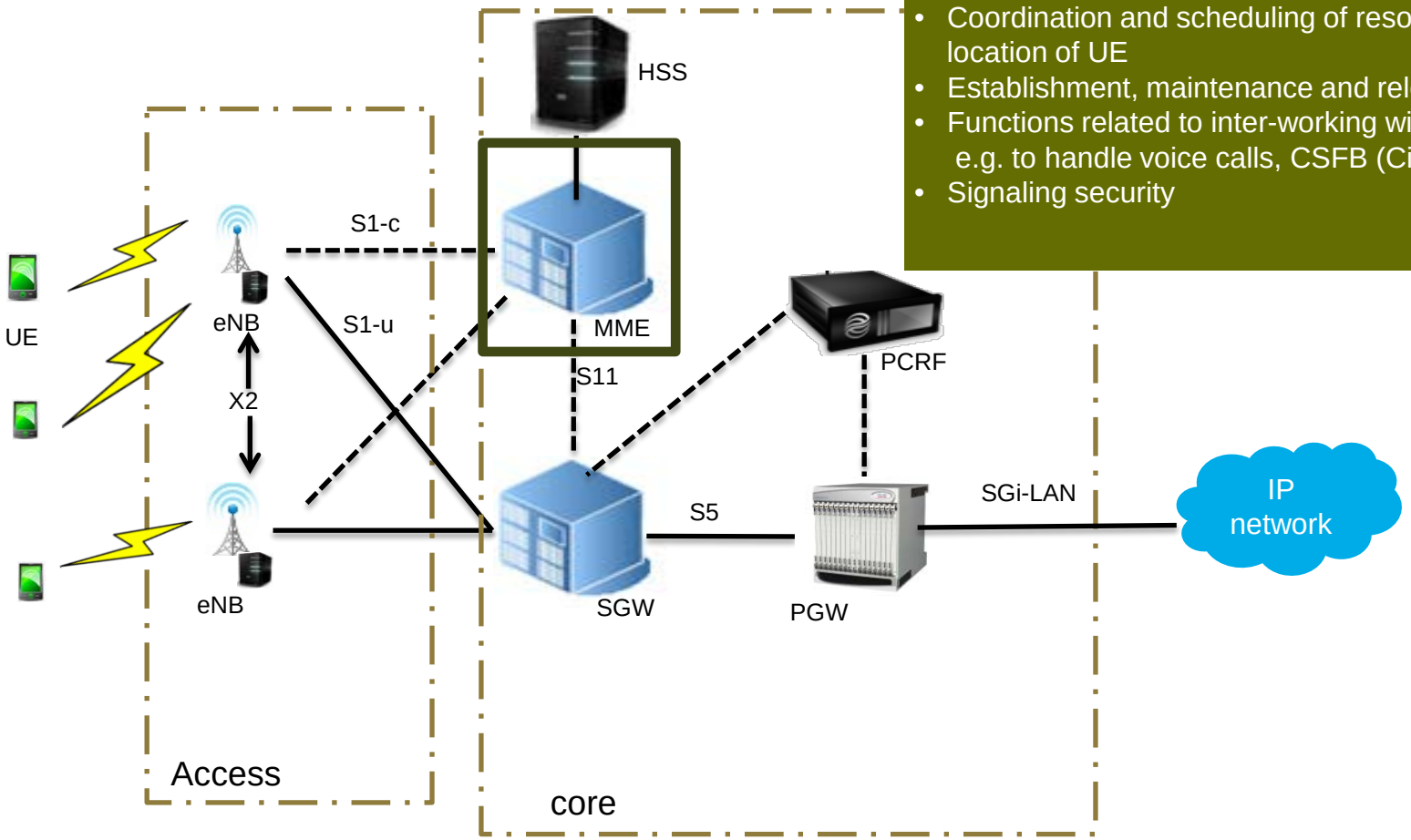
- Local Mobility anchor when UE moves between eNBs
- Temporarily buffers data when MME initiates paging of UE
- Mobility anchor for GPP technologies (GPRS, UMTS)



telenor group

The Network of today

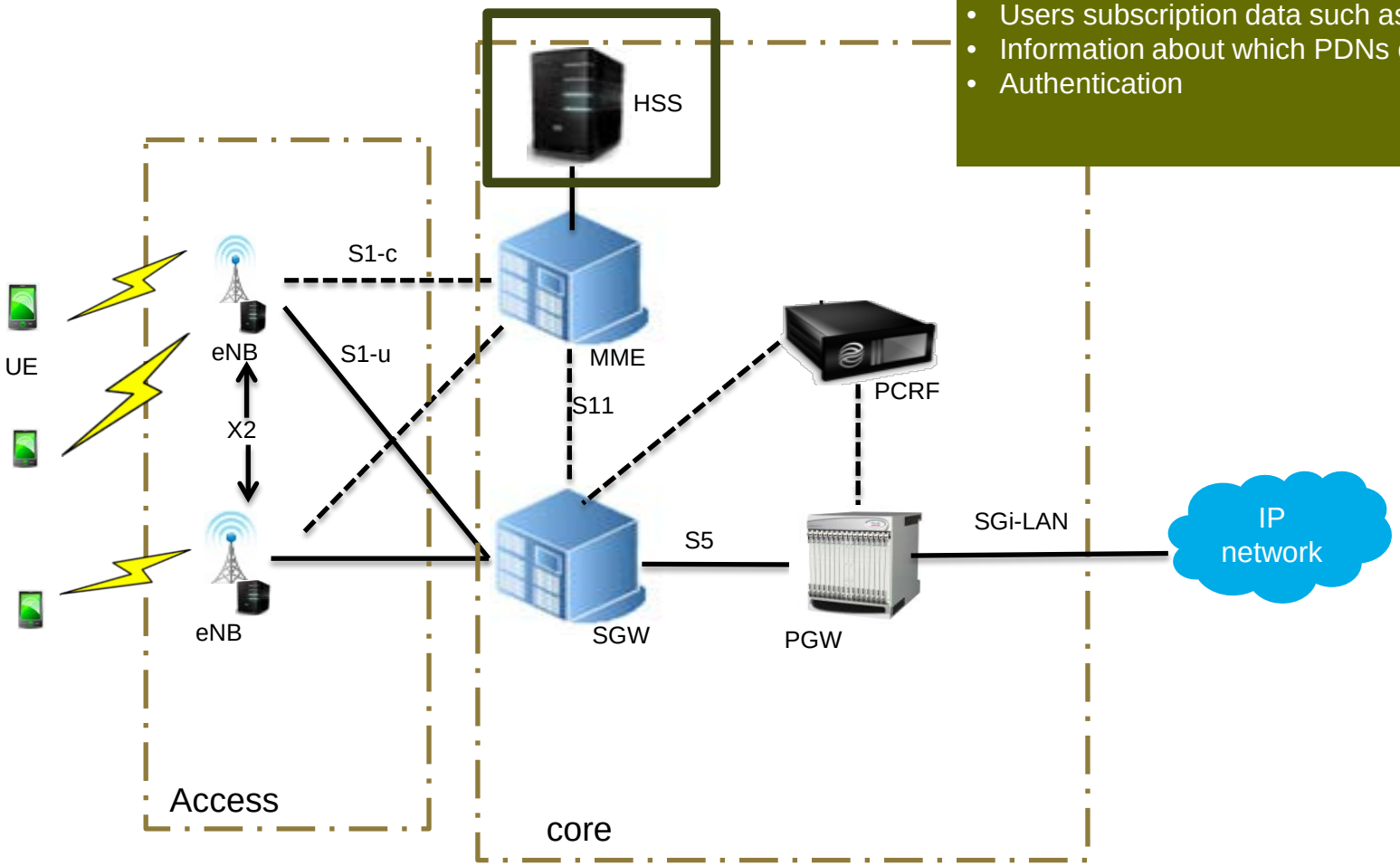
- Processes signaling between UE and core
- Coordination and scheduling of resources related to location of UE
- Establishment, maintenance and release of the bearers
- Functions related to inter-working with other networks
  e.g. to handle voice calls, CSFB (Circuit switch fall back)
- Signaling security



telenor group

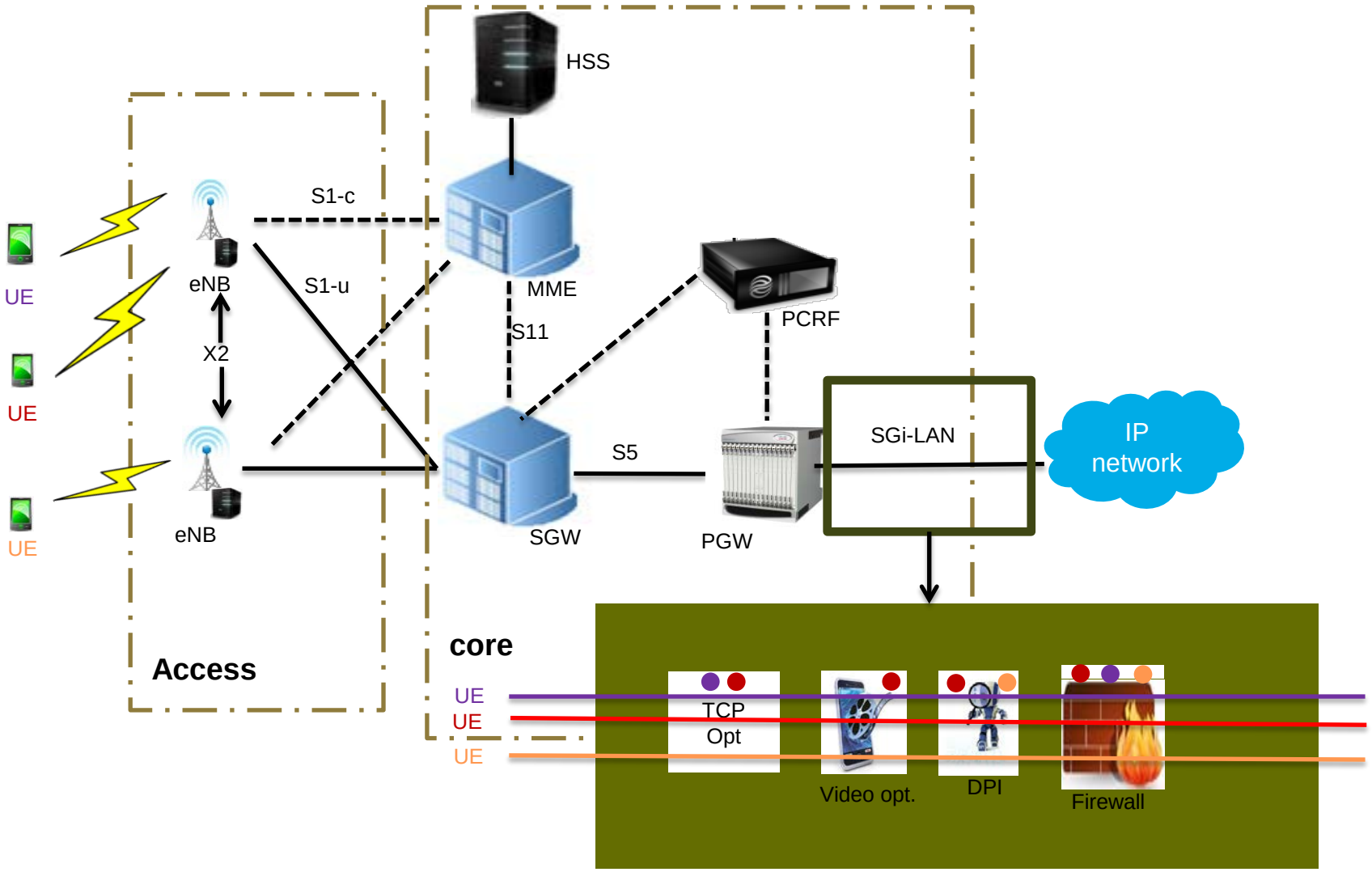
The Network of today

- Users subscription data such as QoS profile
- Information about which PDNs can it connect to
- Authentication



telenor group

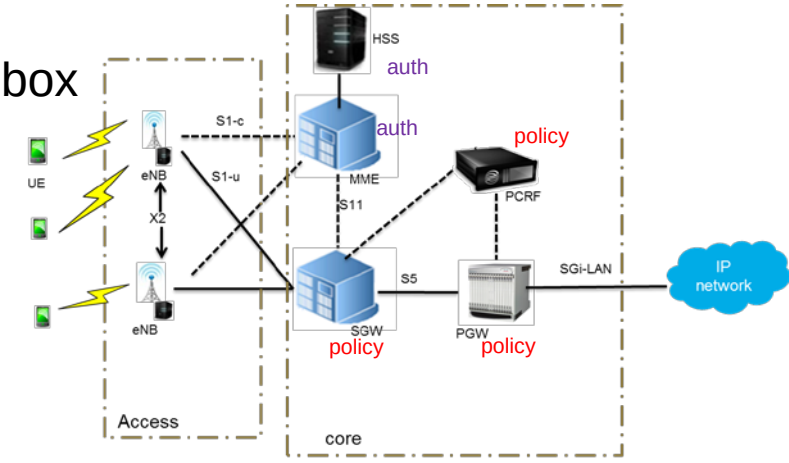
The Network of today



telenor group

Characteristic of the Network of today

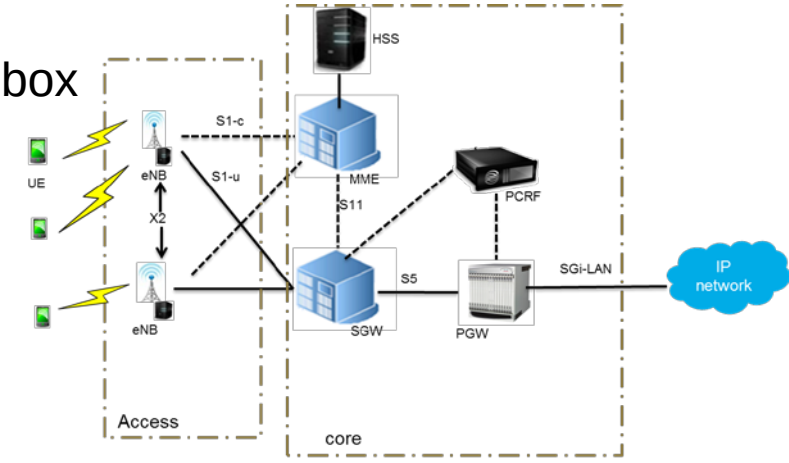
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



telenor group

Characteristic of the Network of today

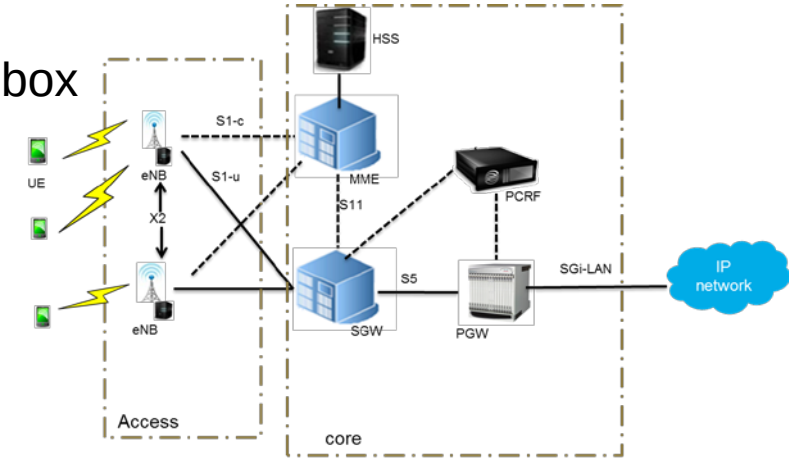
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



telenor group

Characteristic of the Network of today

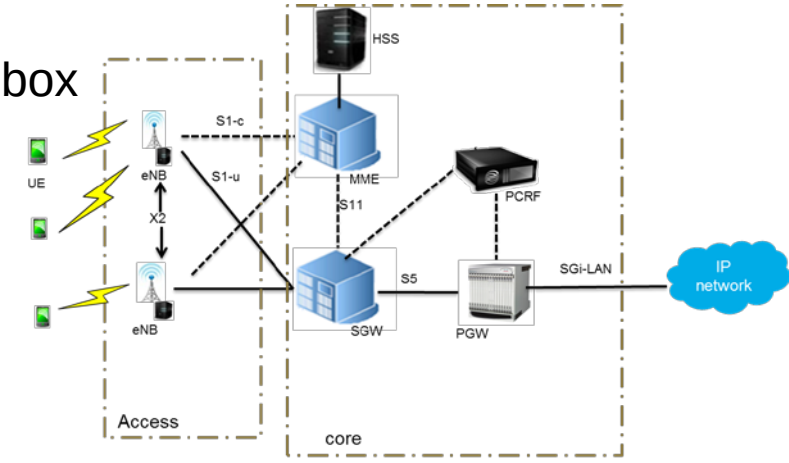
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



telenor group

Characteristic of the Network of today

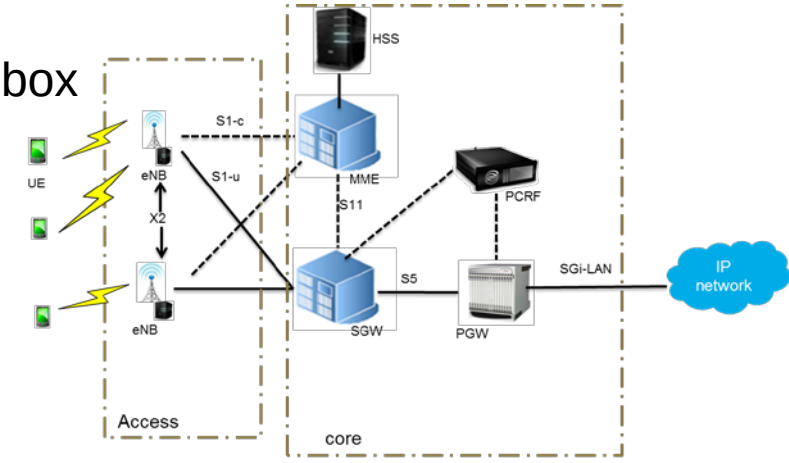
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



telenor group

Characteristic of the Network of today

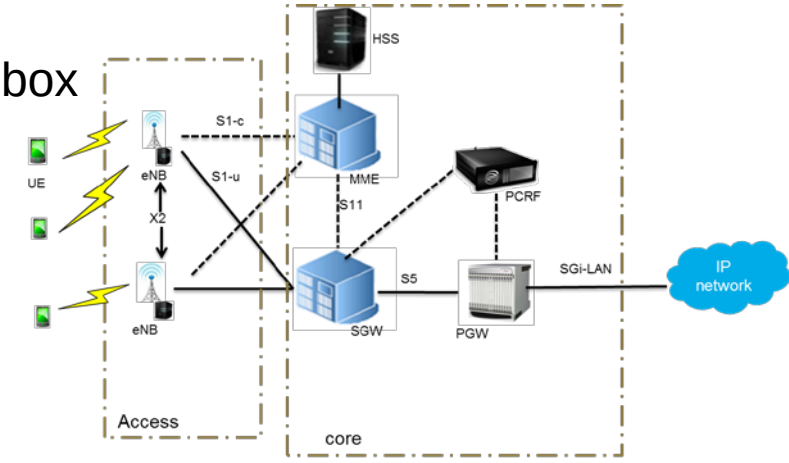
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



telenor group

Characteristic of the Network of today

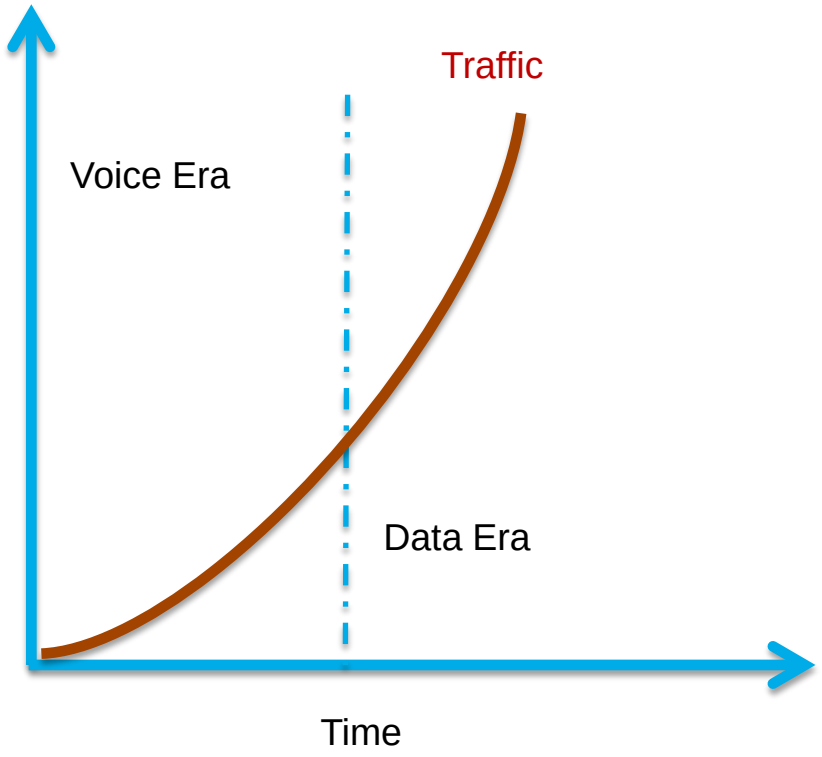
- Topologically fixed network nodes
- Many redundant functions repeated in each black box
- Takes a long tome to roll out new services
  - New services means new equipment
- NOT application aware.
- Statistics of the network difficult to obtain due to the distributed nature of network
- Control logic in each device → difficult to upgrade
- Designed for maximum load but traffic load is fluctuating
  - 80% of base stations (BS) capacity and upto half of core networks capacity unused,*~SoftEPC, ICC'13*



Traffic and revenue

telenor group

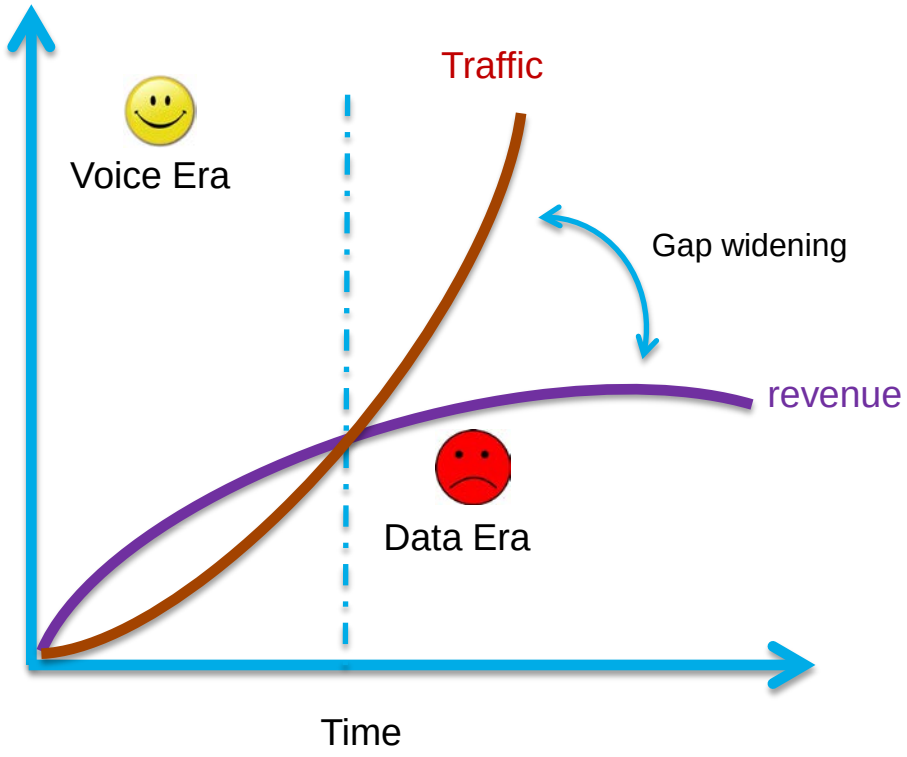
Traffic and Revenue : Traditional Networks



*Trend from unstrung Pyramid research

telenor group

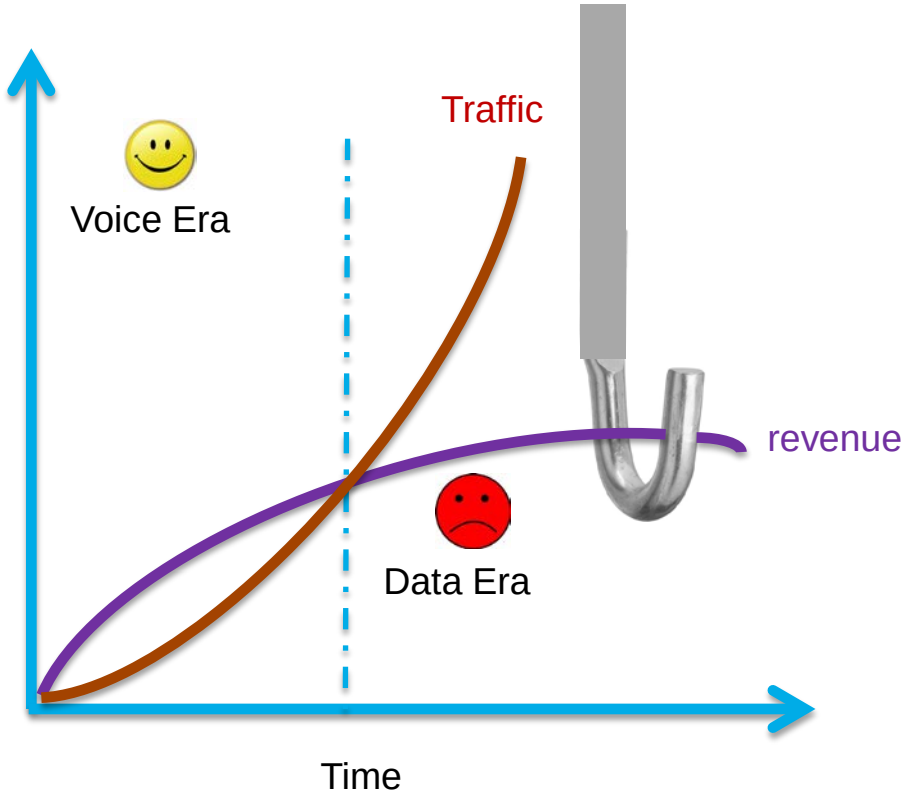
Traffic and Revenue : Traditional Networks



*Trend from unstrung Pyramid research

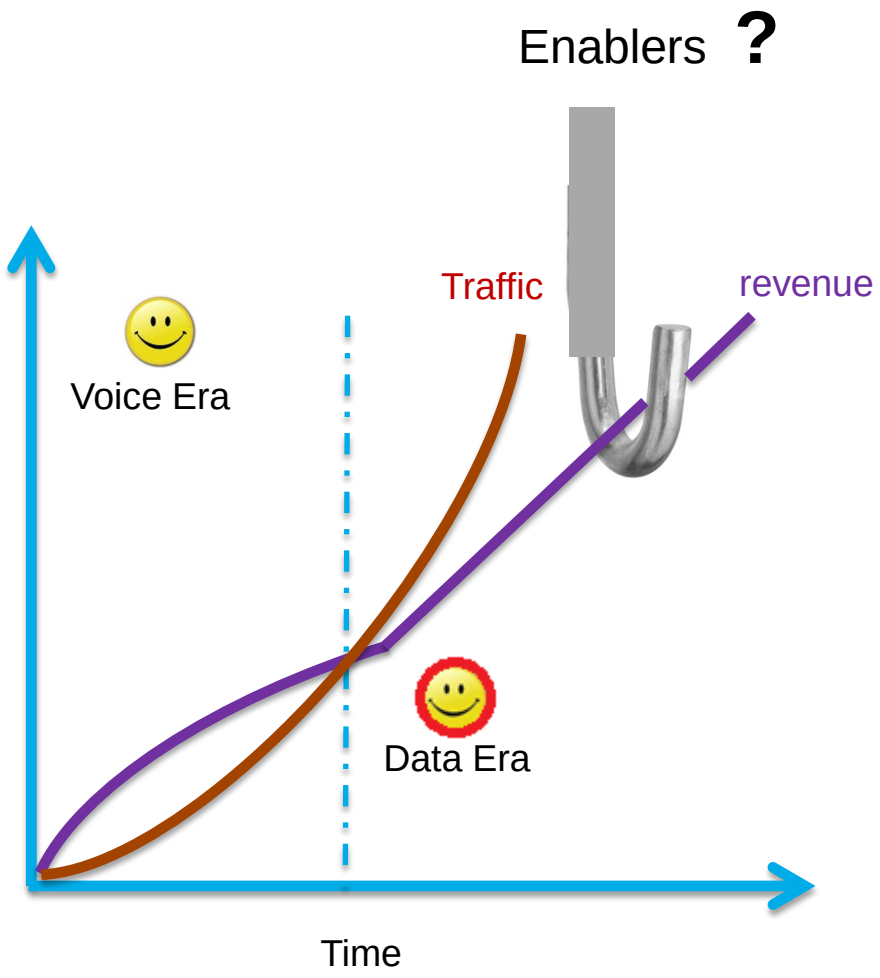
telenor group

Traffic and Revenue : Traditional Networks



*Trend from unstrung Pyramid research

Traffic and Revenue : Elastic networks

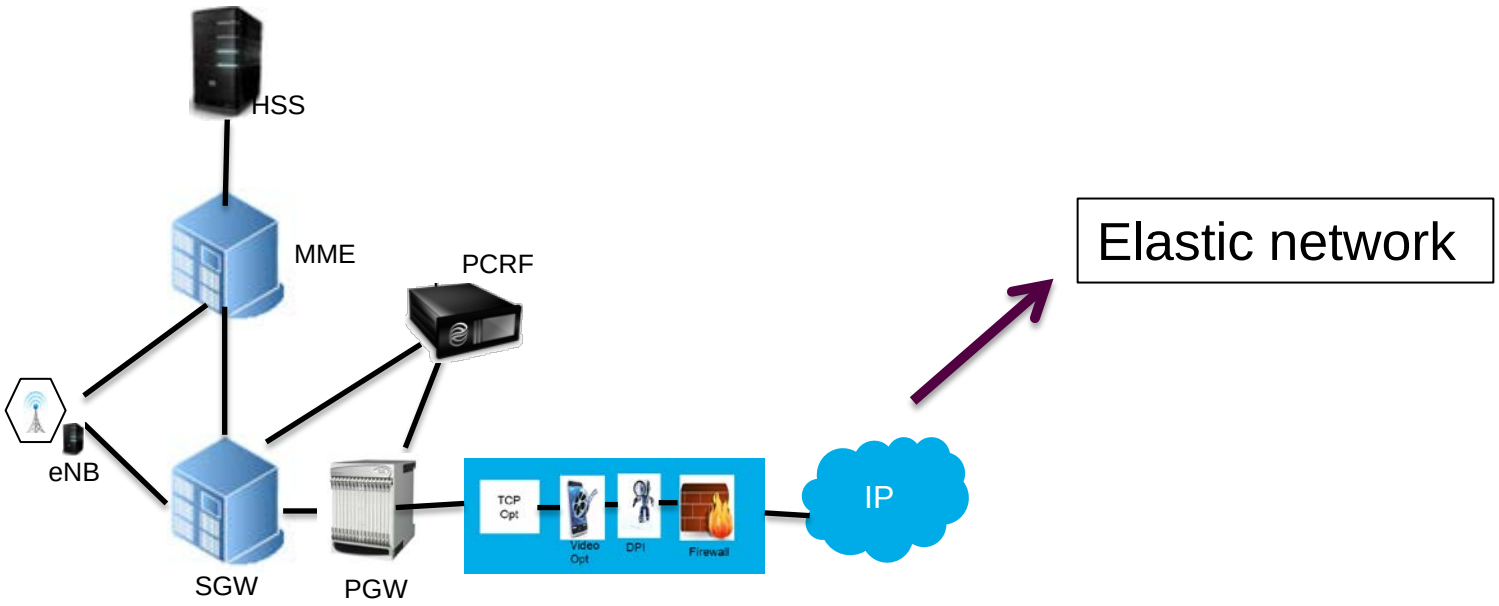


*Trend from unstrung Pyramid research

Outline

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

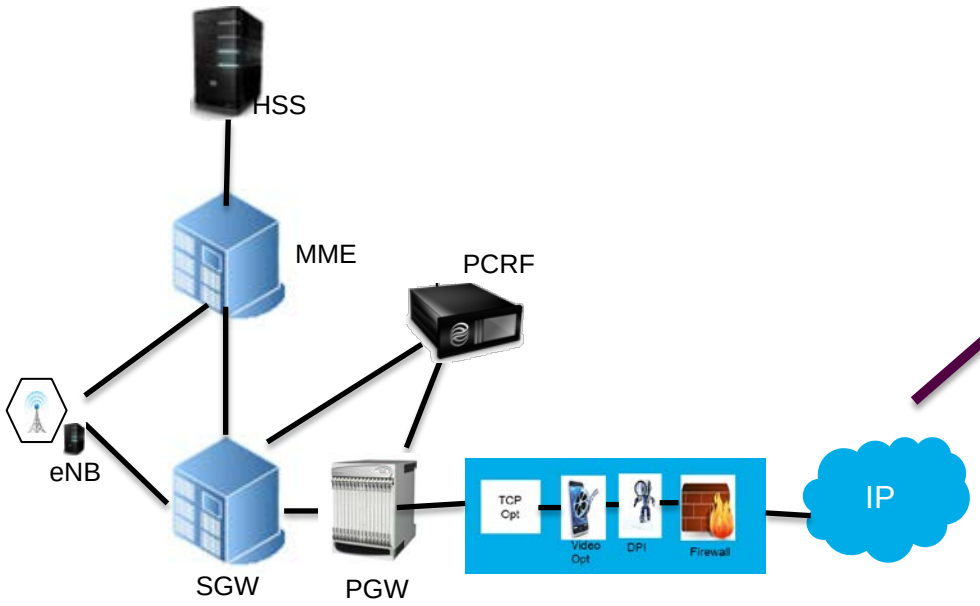
Traditional networks → Elastic Networks



Traditional network

33

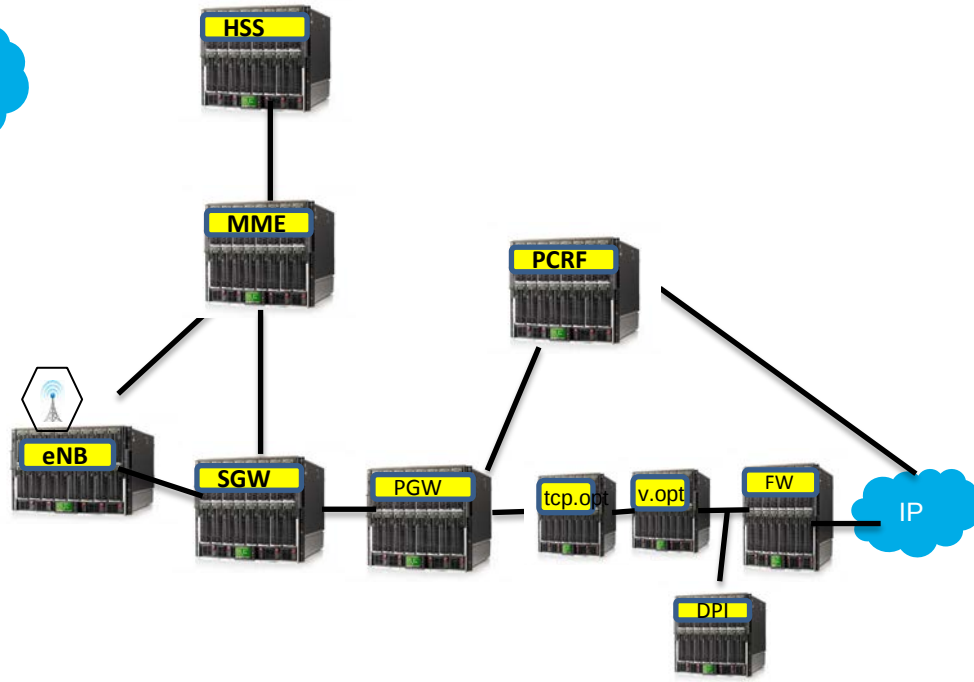
Traditional networks → Elastic Networks



Traditional network

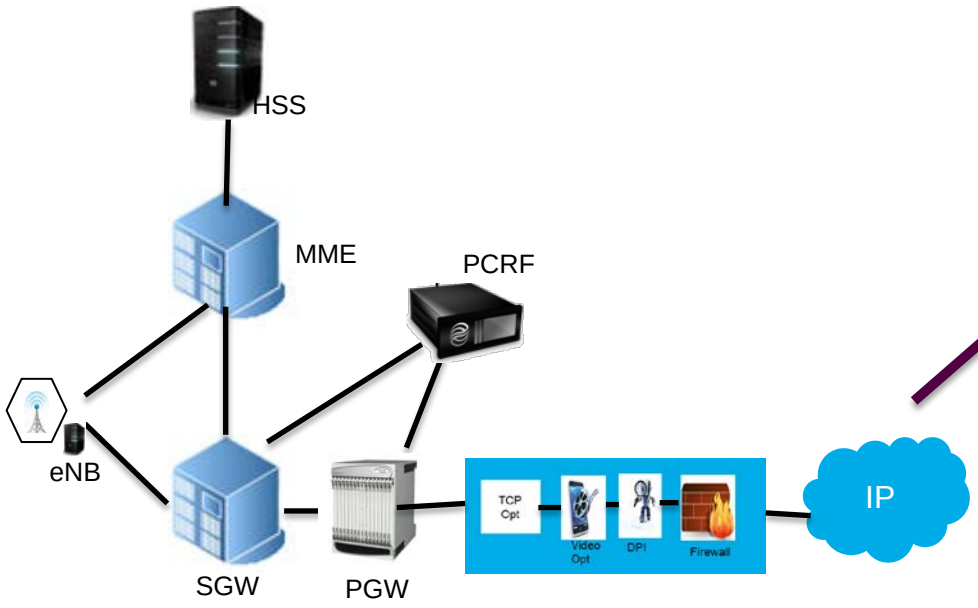
Elastic network

Can scale up and down as well as move resources



34

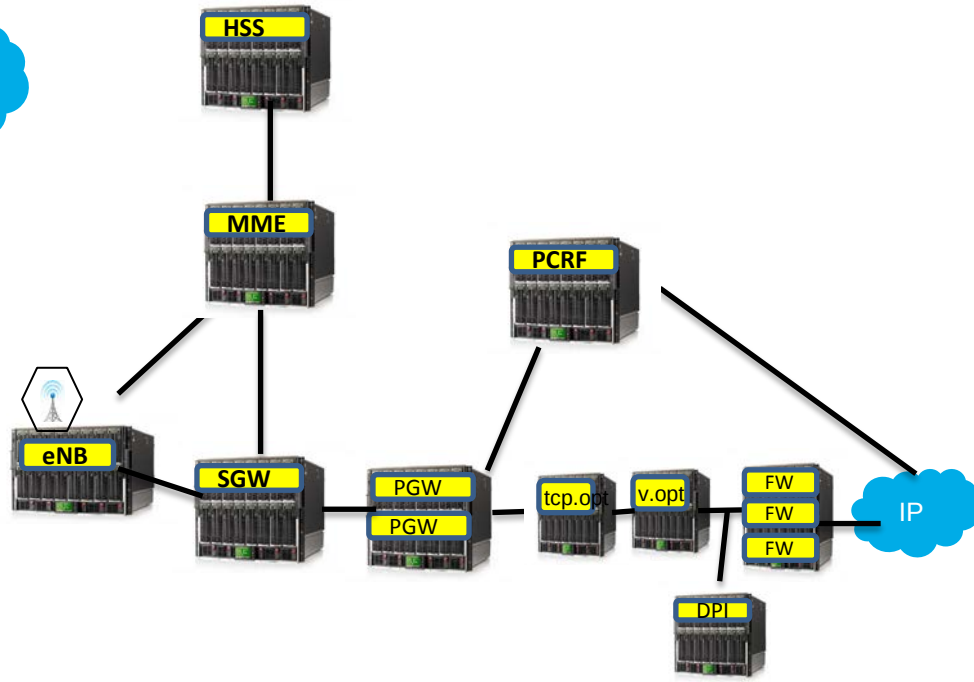
Traditional networks → Elastic Networks



Traditional network

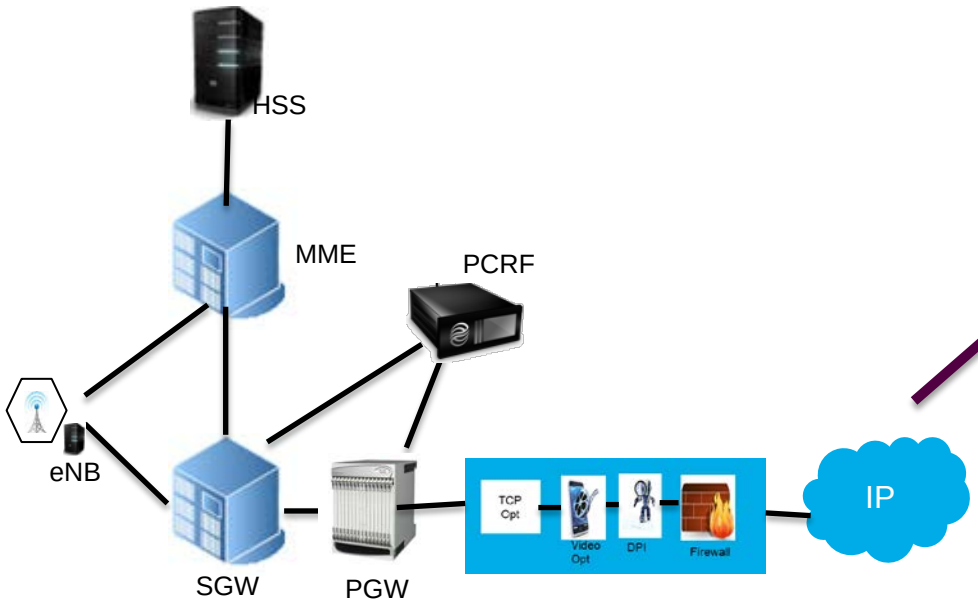
Elastic network

Can scale up and down as well as move resources



35

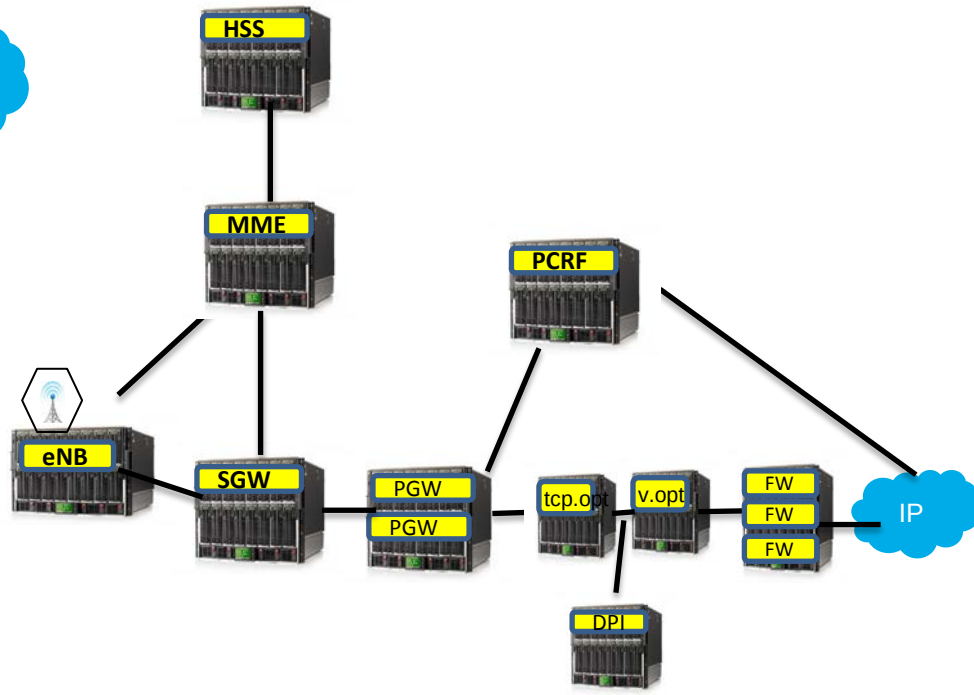
Traditional networks → Elastic Networks



Traditional network

Elastic network

Can scale up and down as well as move resources



Enablers: NFV, SDN

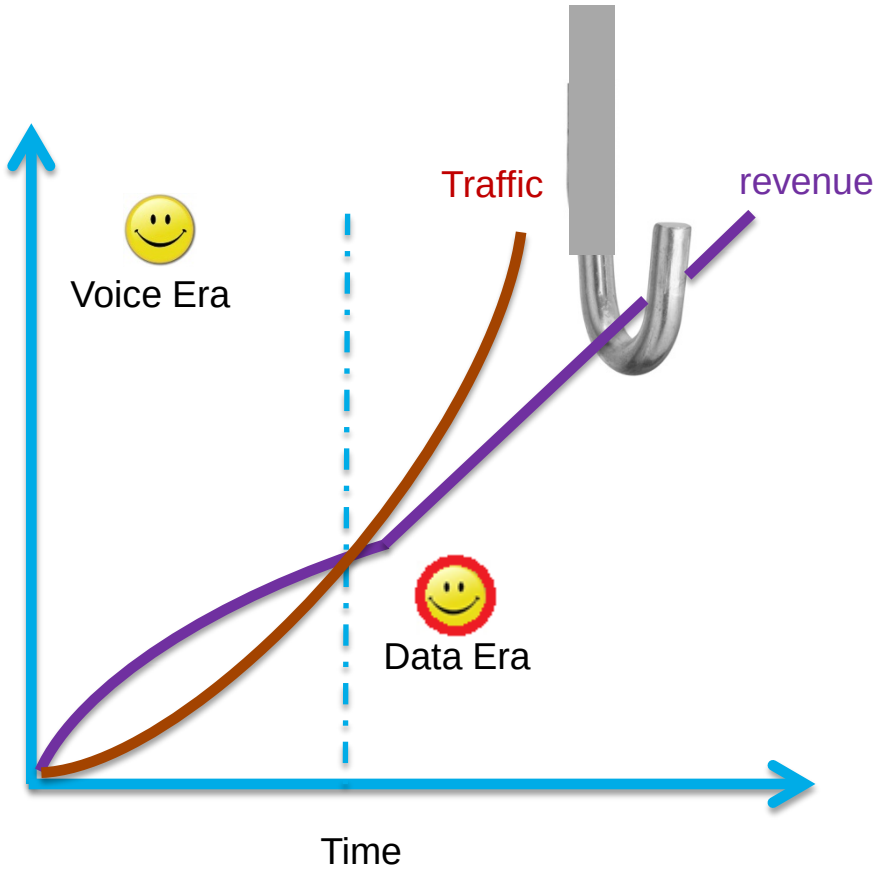
36

Outline

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

Enablers: NFV and SDN

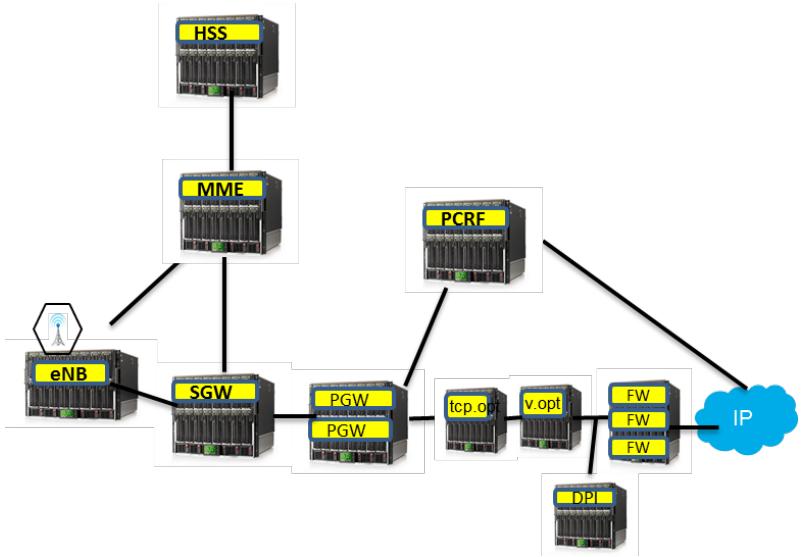
- NFV
- SDN
- …

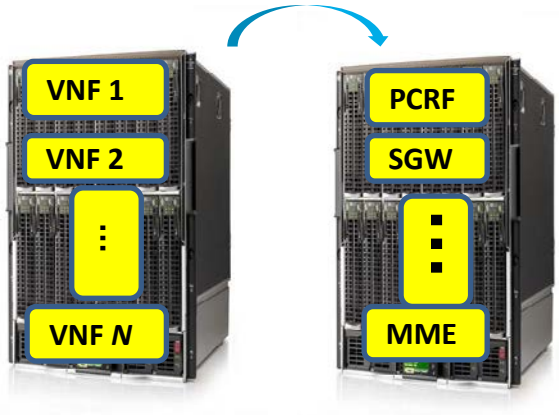


*Trend from unstrung Pyramid research

Network function Virtualization (NFV)

- Network functions are implemented on virtual networks → VNFs
- Almost the same features but more flexibility.
- Uses custom of the shelf (COTS) equipment

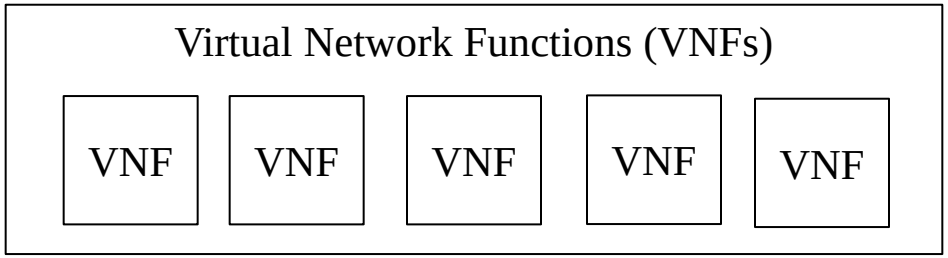




Architecture NFV

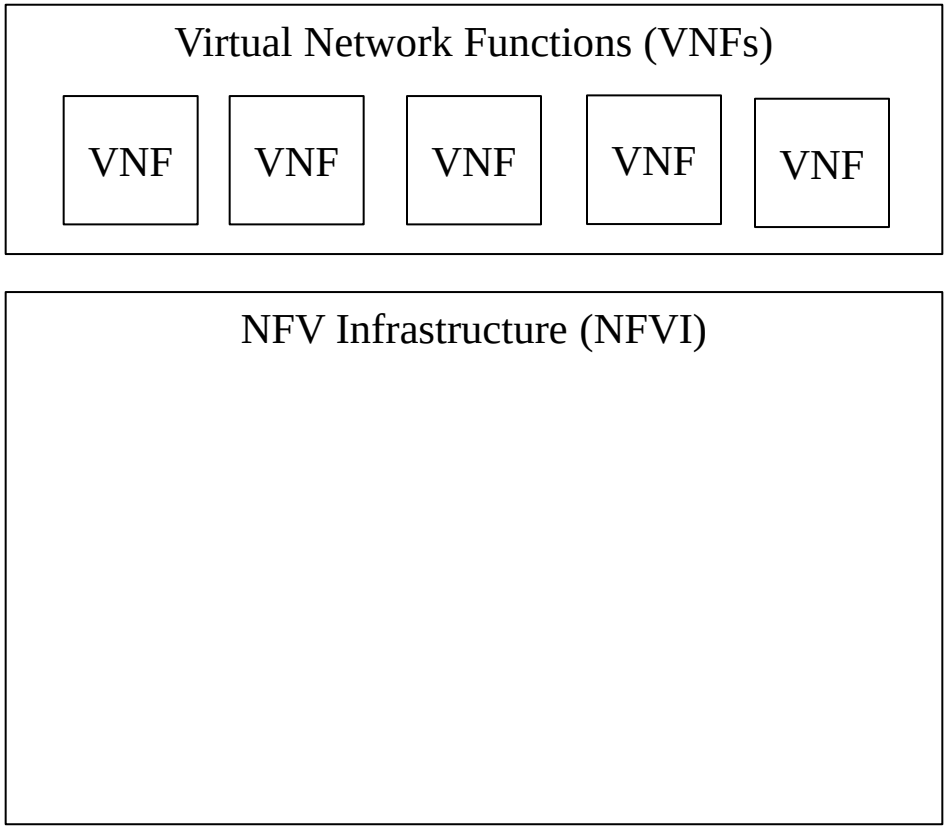
telenor group

Architecture of network virtualization



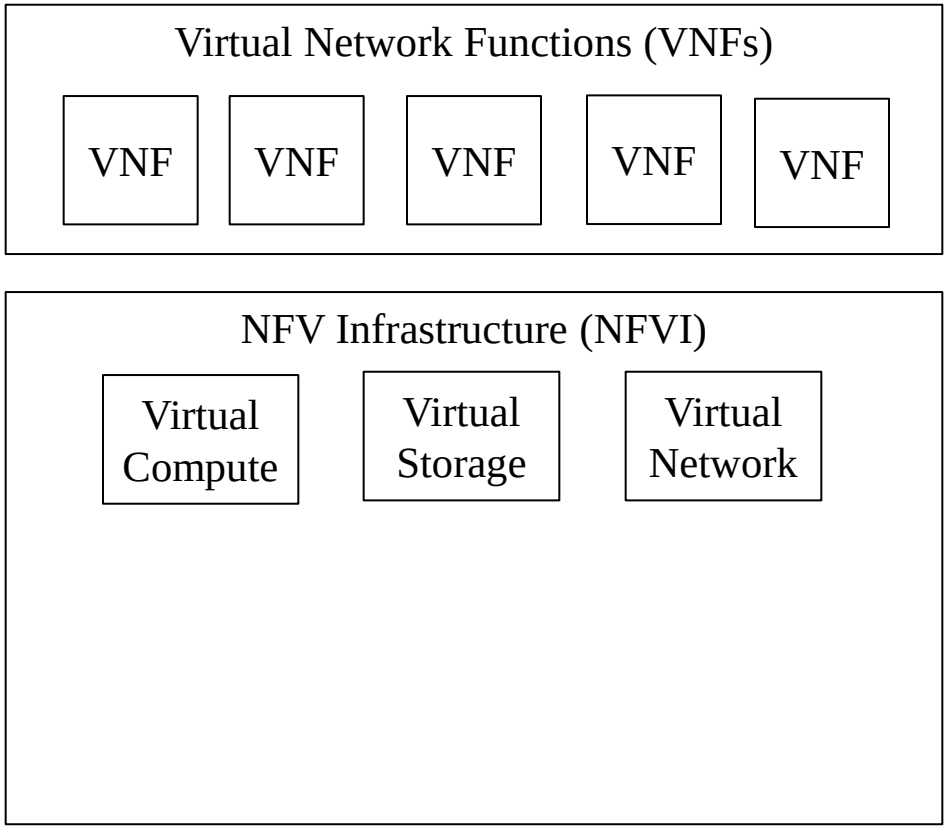
*source : ETSI

Architecture of network virtualization



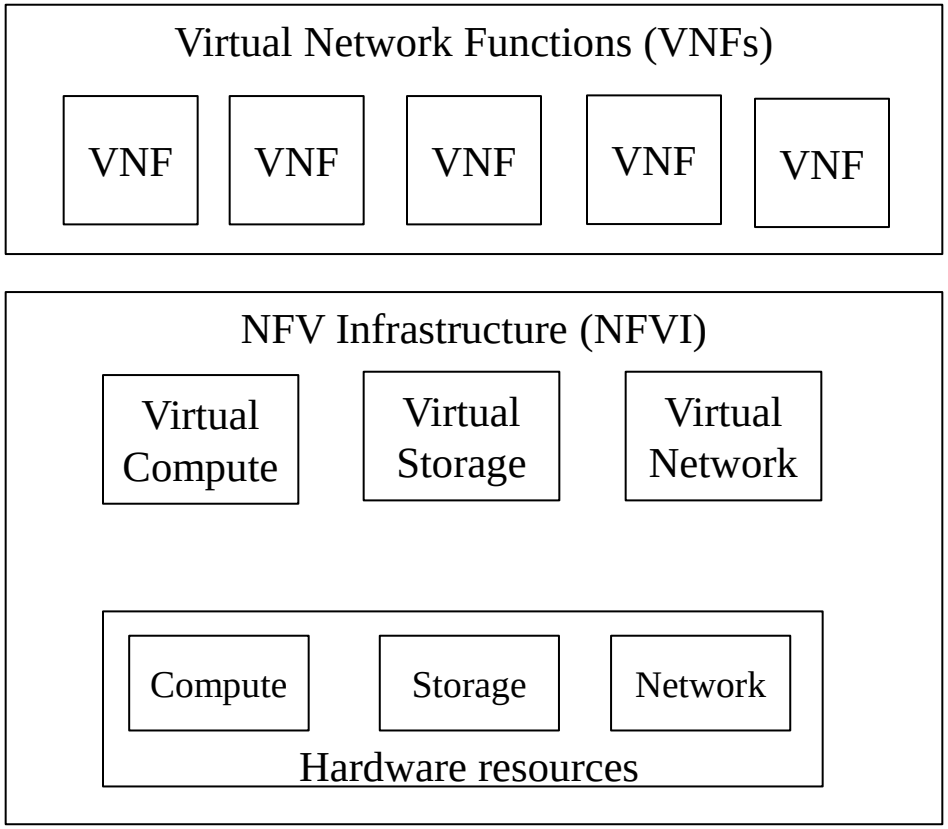
*source : ETSI

Architecture of network virtualization



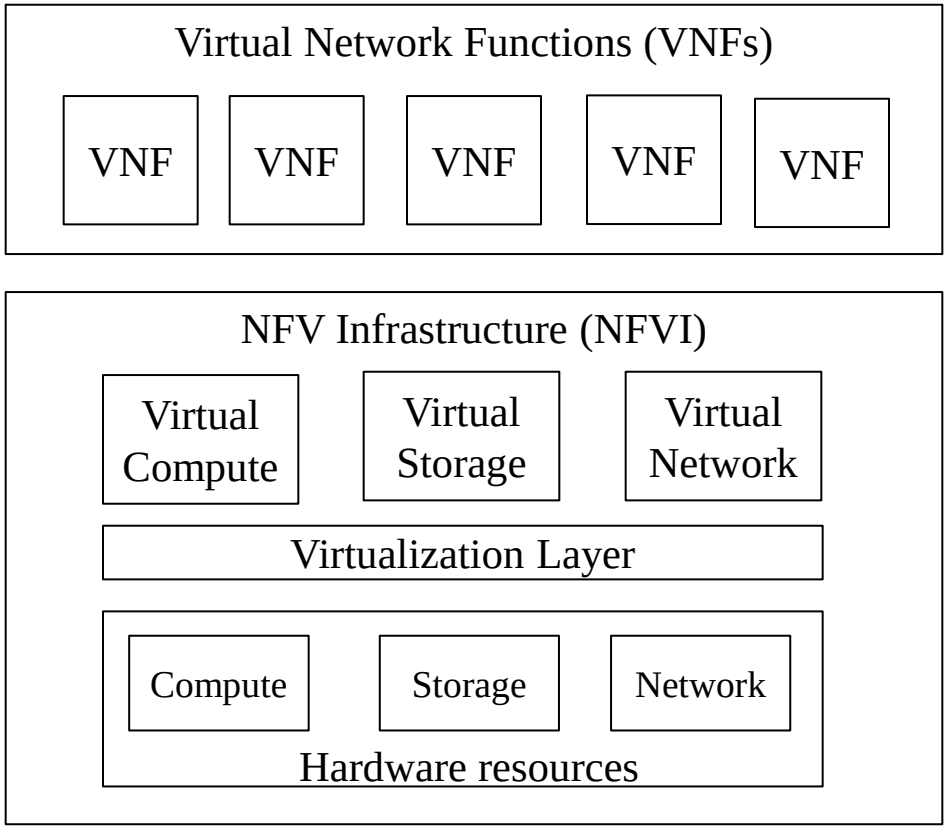
*source : ETSI

Architecture of network virtualization



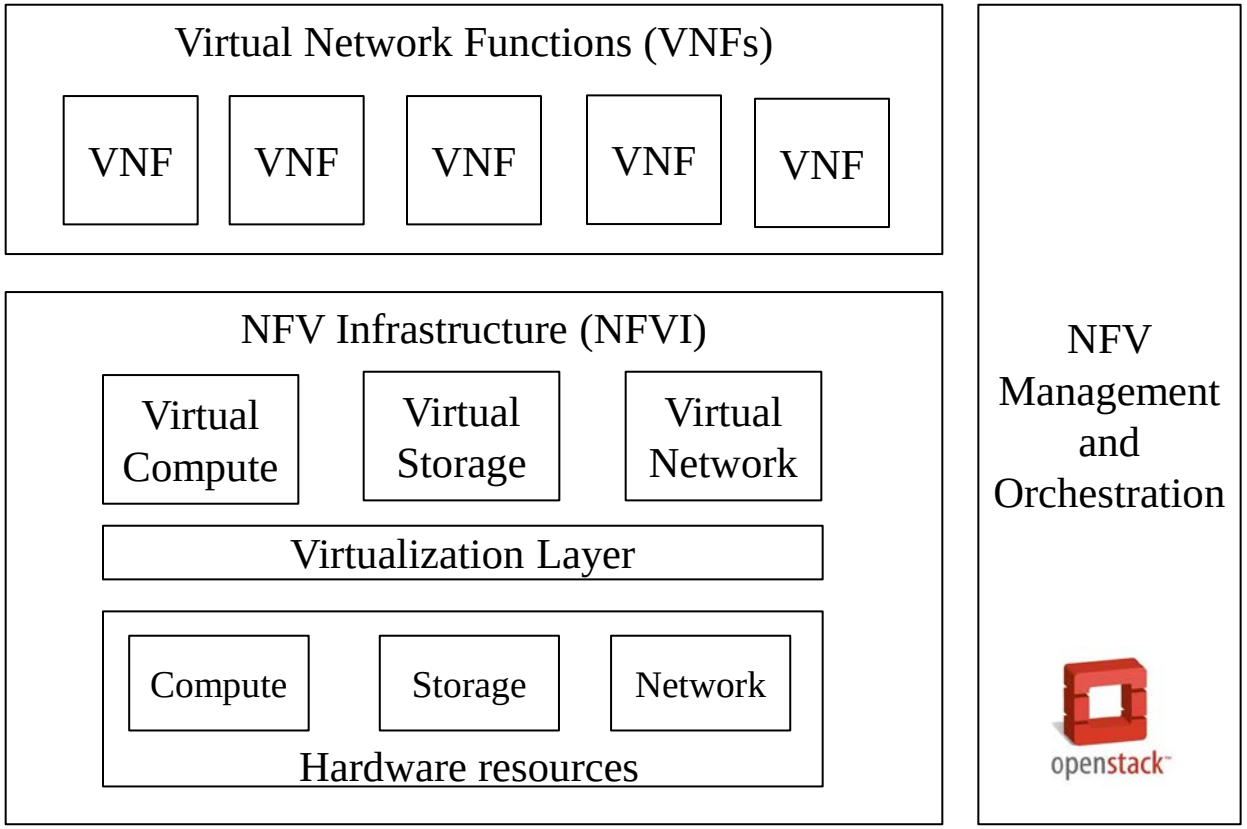
*source : ETSI

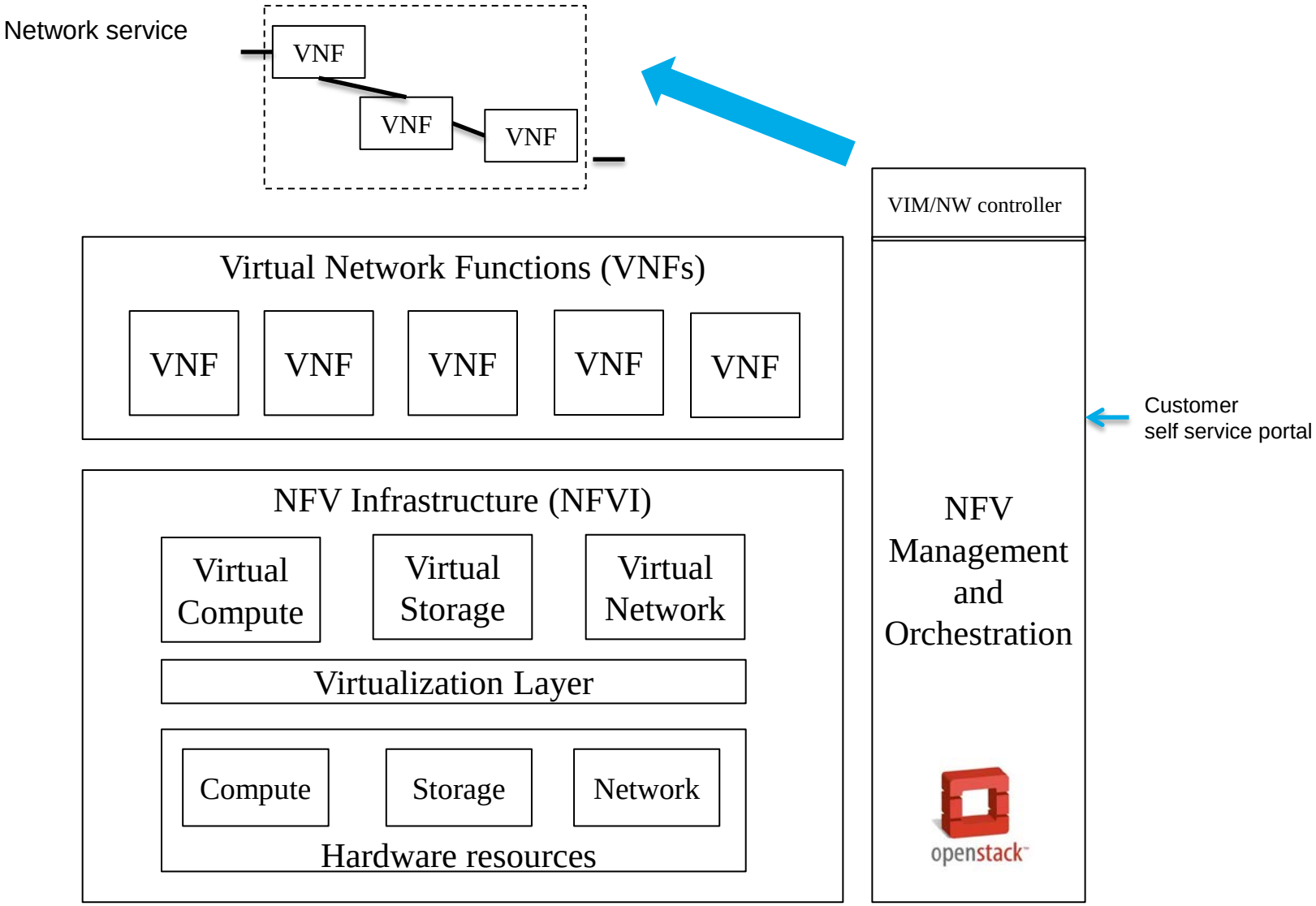
Architecture of network virtualization

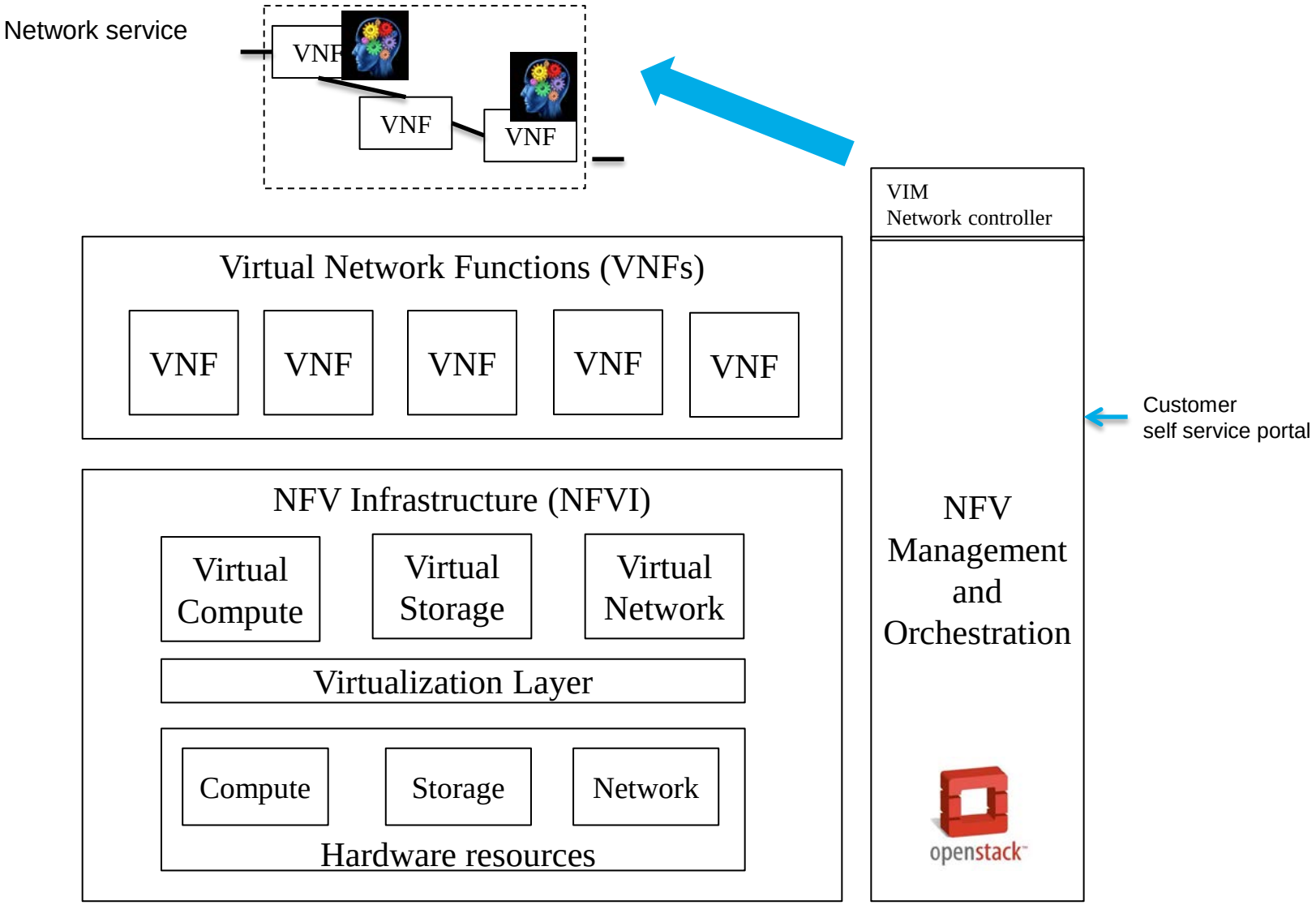


*source : ETSI

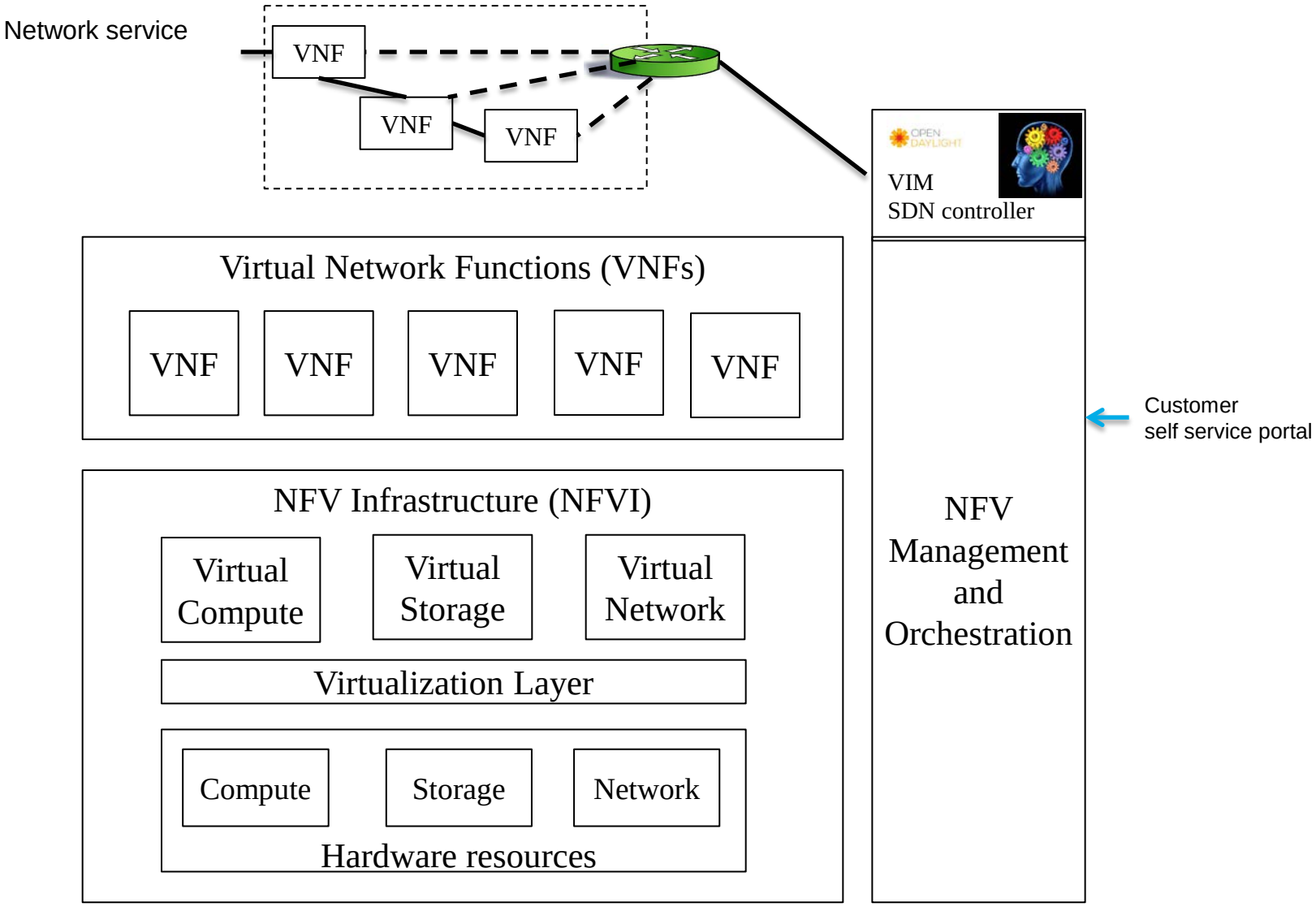
Architecture of network virtualization




Network service
VNF
VNF
VNF
VIM/NW controller
Virtual Network Functions (VNFs)
VNF
VNF
VNF
VNF
VNF
Customer
self service portal
NFV Infrastructure (NFVI)
Virtual Compute
Virtual Storage
Virtual Network
Virtualization Layer
Compute
Storage
Network
Hardware resources
NFV Management and Orchestration
openstack



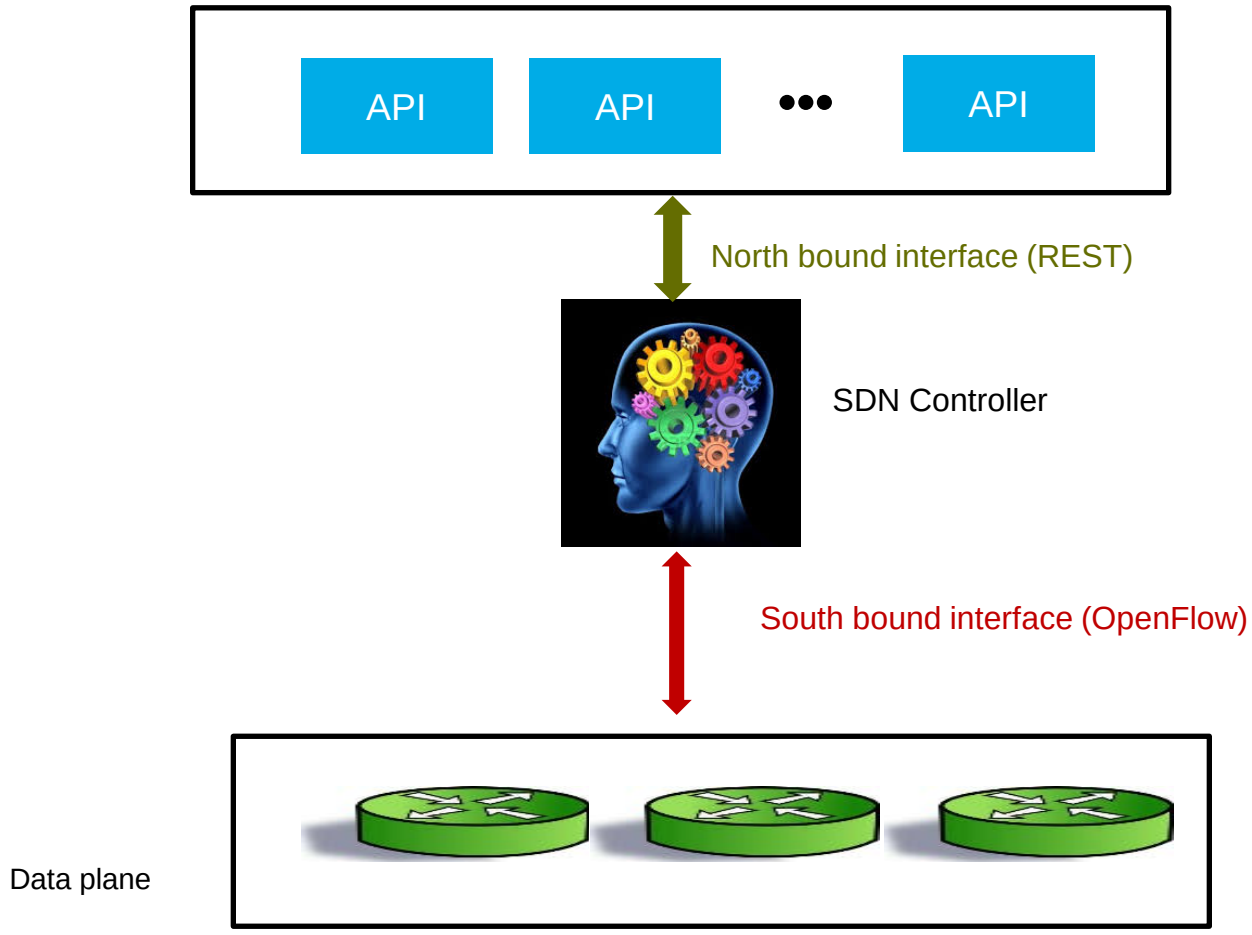
One of the ways to control the network ?



SDN : One of the ways to control the network

Enabler: Software Defined Networking (SDN)

Separate the data plane and the control plane



SDN at work !

- Speaking at the Open Networking Summit in April 2012, Urs Holzle, senior vice-president of technical infrastructure at Google said

- “The company can now prioritize certain traffic, such as Gmail backups, to ensure they get through in a timely manner”

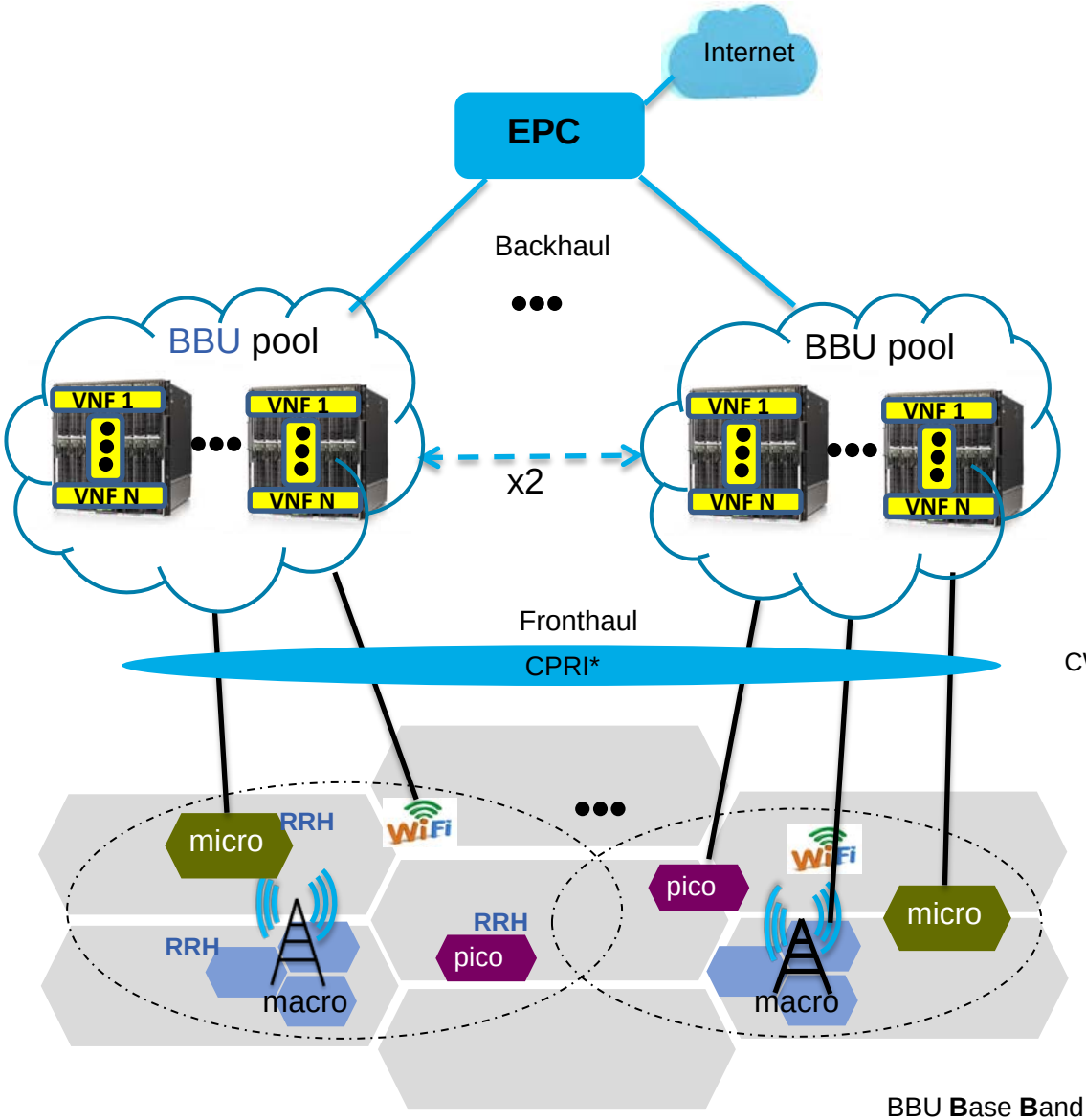
- Perhaps most impressively, Holzle told the conference that,

  “in using SDN to intelligently manage the flow of traffic through its internal network, Google will eventually hit 100% network utilization. In an industry where 30% to 40% is considered standard, that is a huge performance increase.”

Outline

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

vCRAN



BBU **B**ase **B**and Unit
RRH **R**emote Radio Head
CPRI **C**ommon **P**ublic **R**adio **I**nterface

telenor group

vCRAN → Why

- A generic network, supporting different tech 3G, WiFi, 4G, XG and different applications
- Allocating spectrum resources dynamically

telenor group

vCRAN → Why

- A generic network, supporting different tech 3G, WiFi, 4G, XG and different applications
- Allocating spectrum resources dynamically

- LTE-A will use
  - network MIMO
  - coordinated scheduling
  - Interference management

CRAN

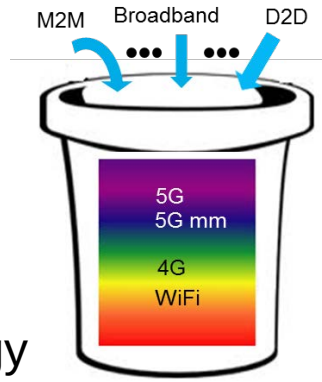
telenor group

vCRAN → Why

- A generic network, supporting different tech 3G, WiFi, 4G, XG and different applications
- Allocating spectrum resources dynamically

- LTE-A will use
  - network MIMO
  - coordinated scheduling
  - Interference management

} **CRAN**



- Liberty of using the slice specific to the type of application and technology

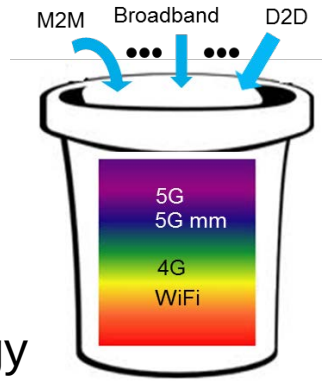
telenor group

vCRAN → Why

- A generic network, supporting different tech 3G, WiFi, 4G, XG and different applications
- Allocating spectrum resources dynamically

- LTE-A will use
  - network MIMO
  - coordinated scheduling
  - Interference management

} **CRAN**



- Liberty of using the slice specific to the type of application and technology

- RAN sharing
  - Active → Only cell sites
  - Passive → In addition to cell sites radio spectrum and baseband processing unit is shared

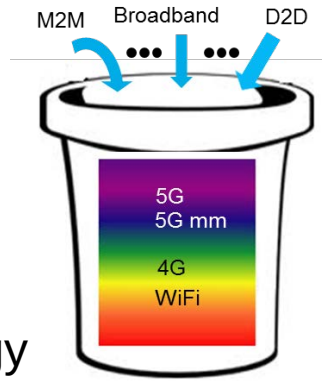
telenor group

vCRAN → Why

- A generic network, supporting different tech 3G, WiFi, 4G, XG and different applications
- Allocating spectrum resources dynamically

- LTE-A will use
  - network MIMO
  - coordinated scheduling
  - Interference management

} **CRAN**



- Liberty of using the slice specific to the type of application and technology

- RAN sharing
  - Active → Only cell sites
  - Passive → In addition to cell sites radio spectrum and baseband processing unit is shared

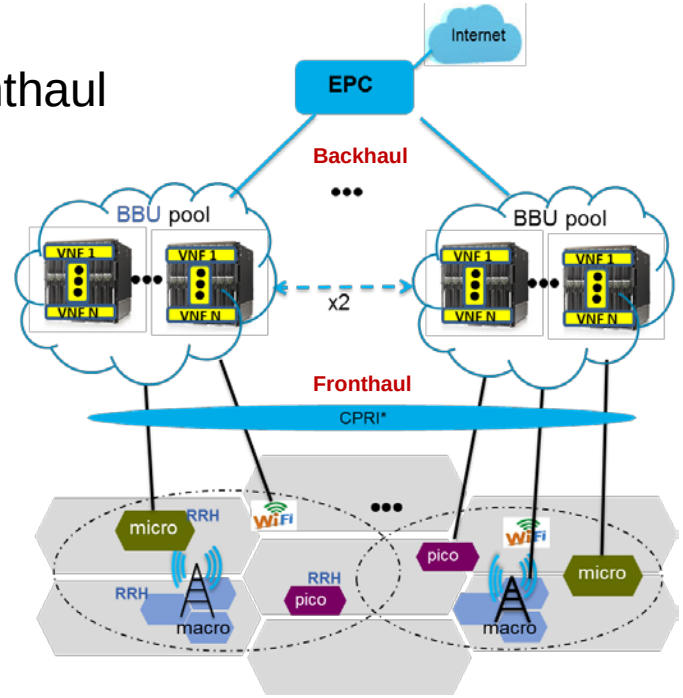
- Age old algorithms on user mobility and traffic patterns can be put into practice
  - leveraging global view and efficient monitoring tools of SDN

- CRAN → Green RAN

telenor group

vCRAN, Challenges

- For centralized CRAN architecture
  - High BW requirement to carry baseband I/Q between BBU and RRH
- Fairness in power, spectrum or product of two
- Fully centralized architecture: requires high capacity fronthaul
- Integration with backhaul.
- CPRI → CWDM, Microwave ?
- Coordination
- Low latency and near zero jitter
- Virtualized solution vs DSP



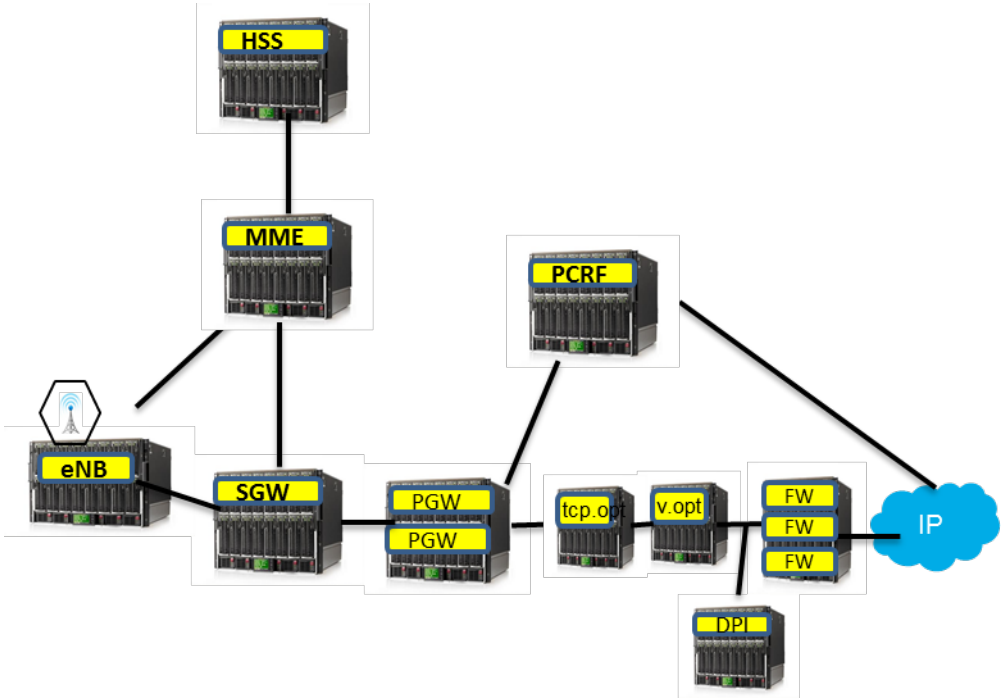
telenor group

Outline

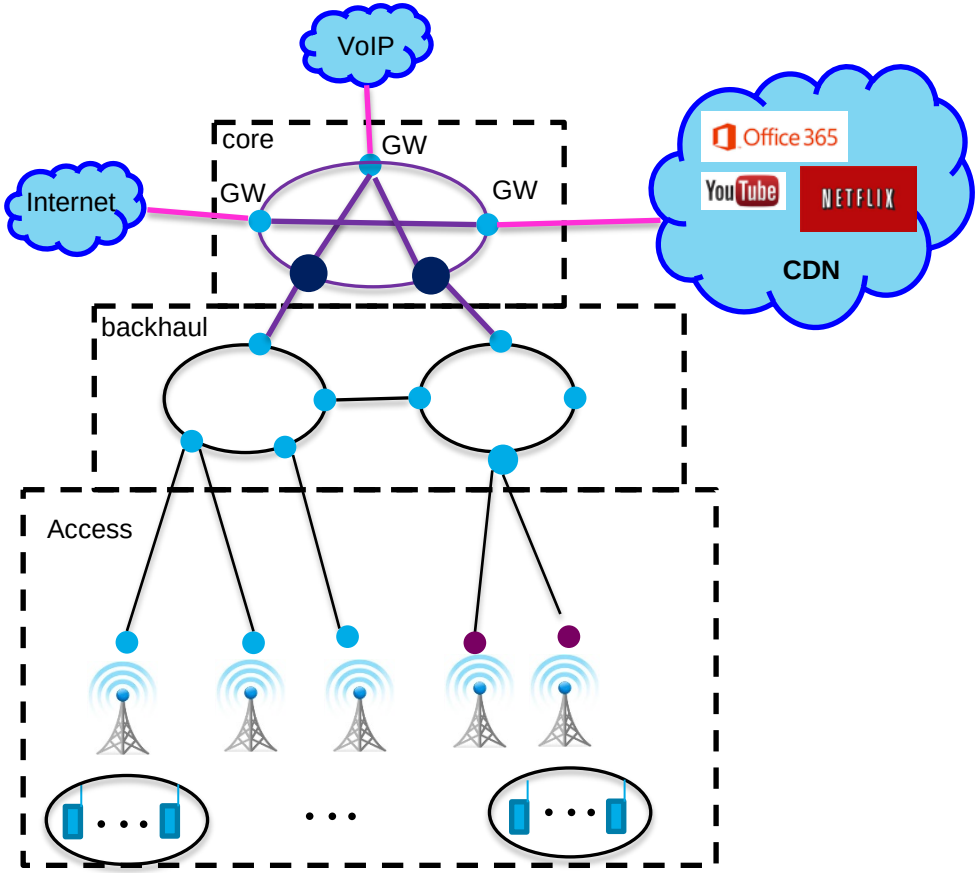
- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion and Outlook

telenor group

vEPC

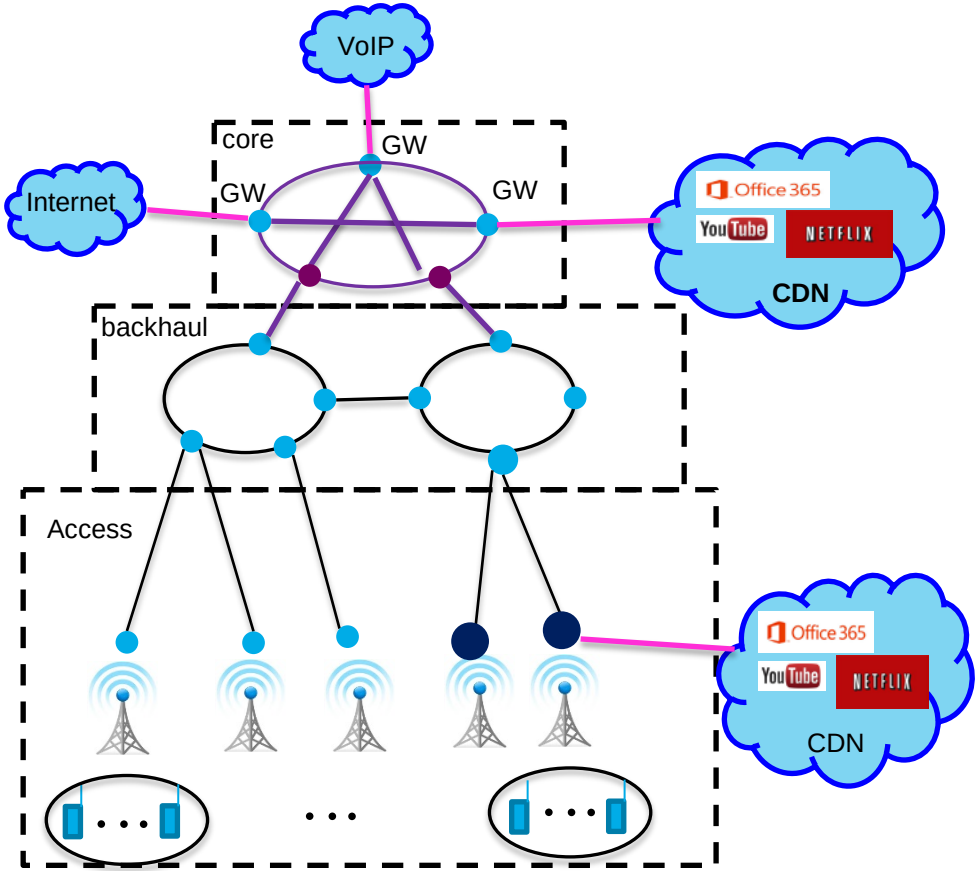


vCDN



telenor group

vCDN



telenor group

In a Nutshell

- Reduction in CAPEX and OPEX.
  - Cost effective → Commodity hardware a plentiful and scalable resource.

- Address new requirements through new software not new equipment.
  - Fast service delivery
  - Bandwidth on demand services

- Integrated RAN → Each slice for different traffic type and technology. Selected by SDN controller. The slice can be scaled up/down → NFV

- Resource pool in the cloud on VMs → NFV

- New abstraction view of networks possible ~ courtesy SDN

- Challenge: Cost and Performance analysis of virtualizing network functions

telenor group

In a Nutshell

- Reduction in CAPEX and OPEX.
  - Cost effective → Commodity hardware a plentiful and scalable resource.

- Address new requirements through new software not new equipment.
  - Fast service delivery
  - Bandwidth on demand services

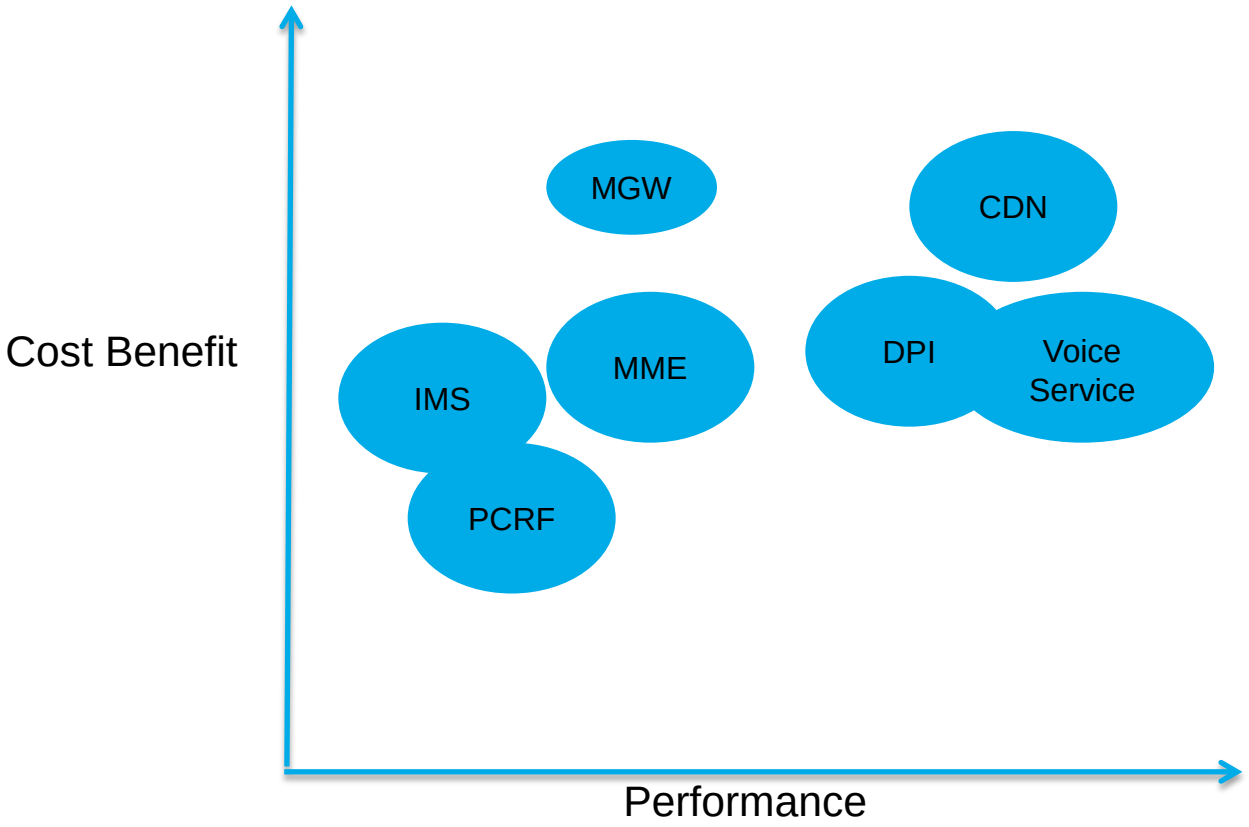
- Integrated RAN → Each slice for different traffic type and technology. Selected by SDN controller. The slice can be scaled up/down → NFV

- Resource pool in the cloud on VMs → NFV

- New abstraction view of networks possible ~ courtesy SDN

- Challenge: Cost and Performance analysis of virtualizing network functions

Cost and Performance Analysis : Expected Outcome



Contributors

telenor group

Performance Analysis

Low level variable	Description	Strategic Results variable
Link utilization	Percentage of total link utilization between two points in the network. VNFs can be located at different locations in the network → Impacts link utilization.	Cost, performance
Resource utilization	NFV has the potential to reduce resource utilization since multiple VNFs can be installed on COTS hardware. How will the virtualisation of the function impact utilization of the hardware, i.e. router, switches, servers and storage?	Cost, performance
Energy consumption	Can be reduced by consolidating equipment and exploit power management features in standard servers and storage, as well as workload consolidation and location optimization.	Cost, performance

telenor group

Performance Analysis

Low level variable	Description	Strategic Results variable
Link utilization	Percentage of total link utilization between two points in the network. VNFs can be located at different locations in the network → Impacts link utilization.	Cost, performance
Resource utilization	NFV has the potential to reduce resource utilization since multiple VNFs can be installed on COTS hardware. How will the virtualisation of the function impact utilization of the hardware, i.e. router, switches, servers and storage?	Cost, performance
Energy consumption	Can be reduced by consolidating equipment and exploit power management features in standard servers and storage, as well as workload consolidation and location optimization.	Cost, performance
Portability	Concerns the capabilities to load, execute and move software functions across different but standard data centres and network locations.	Cost
Elasticity	Concerns the capabilities to provide an easier way to scale up/down and in/out hardware and software resources as traffic demands increase/decreases.	Cost

telenor group

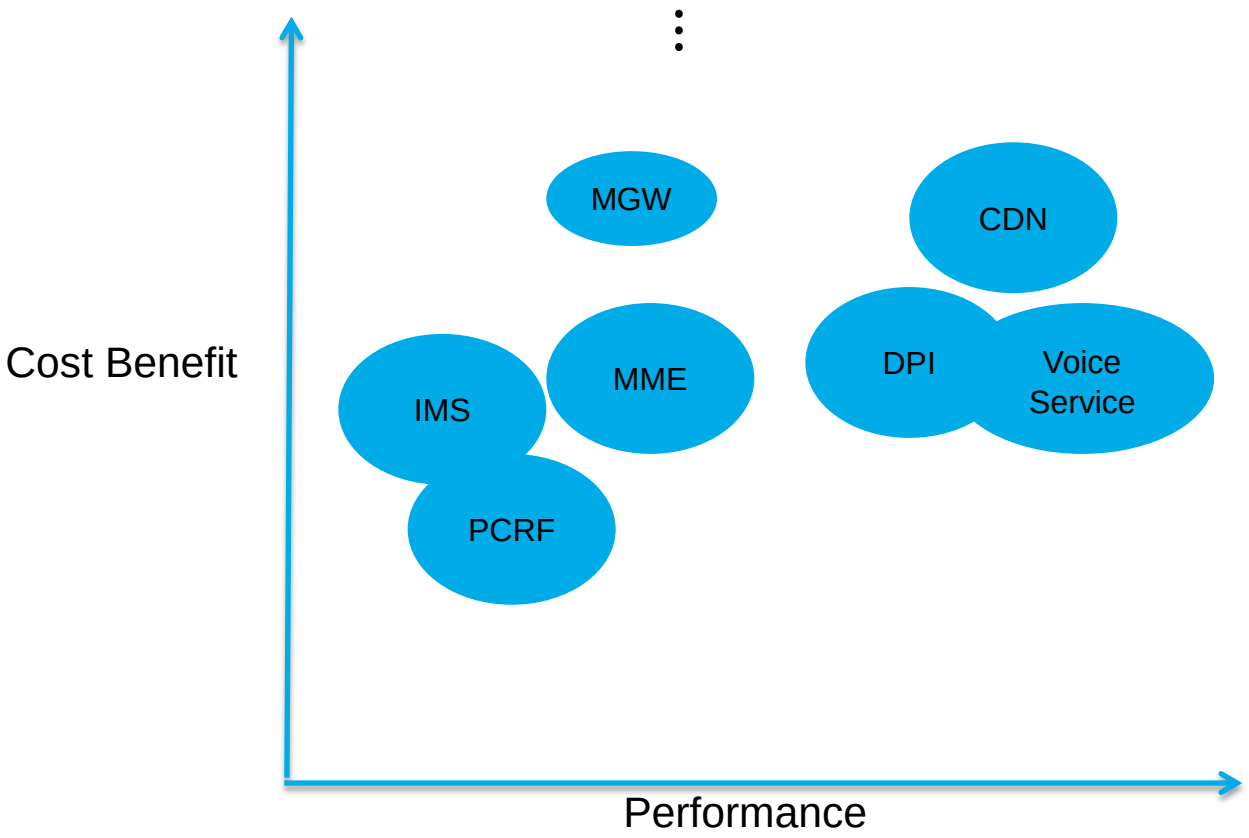
Performance Analysis

Low level variable	Description	Strategic Results variable
Link utilization	Percentage of total link utilization between two points in the network. VNFs can be located at different locations in the network → Impacts link utilization.	Cost, performance
Resource utilization	NFV has the potential to reduce resource utilization since multiple VNFs can be installed on COTS hardware. How will the virtualisation of the function impact utilization of the hardware, i.e. router, switches, servers and storage?	Cost, performance
Energy consumption	Can be reduced by consolidating equipment and exploit power management features in standard servers and storage, as well as workload consolidation and location optimization.	Cost, performance
Portability	Concerns the capabilities to load, execute and move software functions across different but standard data centres and network locations.	Cost
Elasticity	Concerns the capabilities to provide an easier way to scale up/down and in/out hardware and software resources as traffic demands increase/decreases.	Cost
Realtime properties	Delay, jitter, latency etc.	Performance
Security	How will the transition from physical to virtual network functions impact security? The role of SDN as a centralized controller could have an effect on security	Performance

Performance Analysis : Expected Outcome

$$CostBenefit_{MME} = w^{MME}{}_{CB,LU}.Link\ Utilization + w^{MME}{}_{CB,Por}.Portability + \cdots$$
$$Performance_{MME} = w^{MME}{}_{Per,LU}.Link\ Utilization + w^{MME}{}_{Per,EC}.EnergyConsumption + \cdots$$

$$CostBenefit_{PCRF} = w^{PCRF}{}_{CB,LU}.Link\ Utilization + w^{PCRF}{}_{CB,Por}.Portability + \cdots$$
$$Performance_{PCRF} = w^{PCRF}{}_{Per,LU}.Link\ Utilization + w^{PCRF}{}_{Per,EC}.EnergyConsumption + \cdots$$



telenor group

Final-line

- Challenges → What is coming
- The Network of today
- Elastic Networks → Way forward
- Enablers for Elastic networks → NFV / SDN
- Use cases
  - vCRAN
  - vEPC
  - vCDN
- Conclusion

Thank You

kashif.mahmood@telenor.com

Next Generation Network Technology Group,
Telenor research, Norway

telenor group