Slicing and Orchestration in Service-Oriented 5G Networks

Navid Nikaein

Associate Professor - Eurecom

Coordinator of Mosaic-5G Initiative

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Connected, Controlled, and Flexible
Digital Society
Value Creation
Consistent experience
Sustainable business model

5G Promises

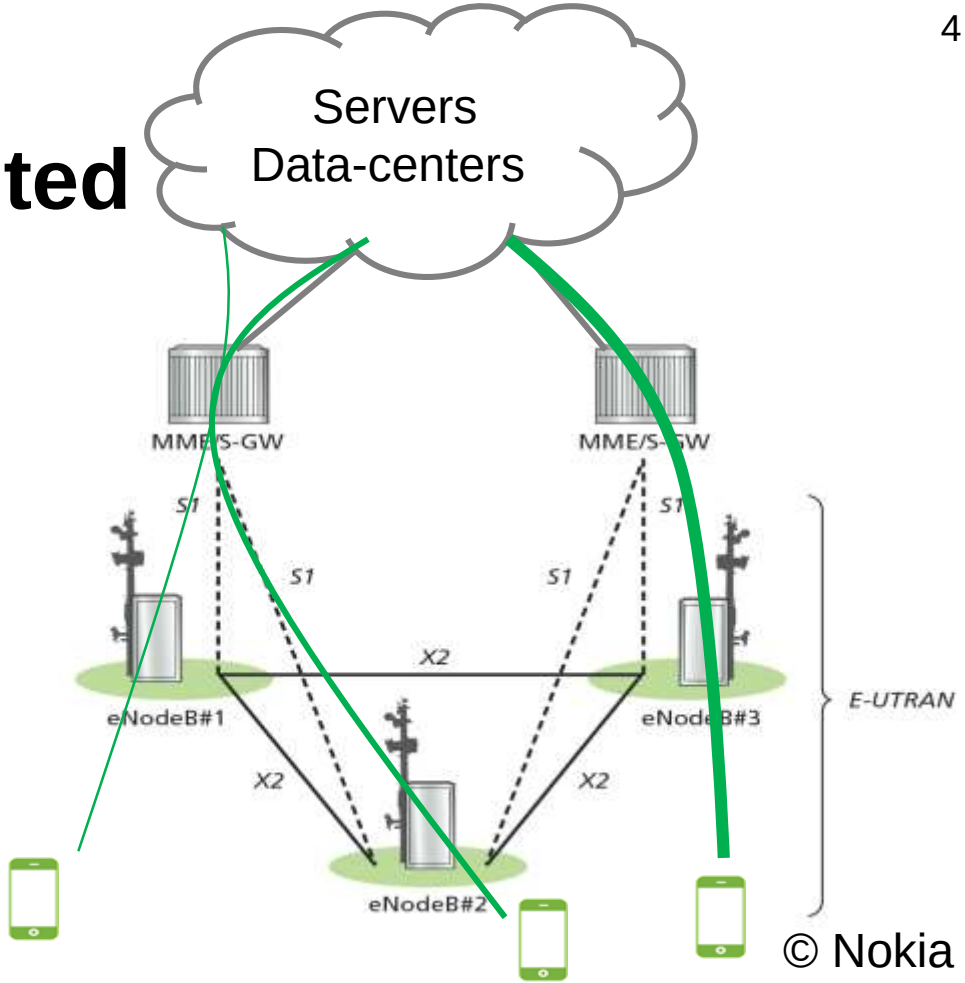
Source: Dohler

Evolution to Internet of Skills

Communication-Oriented

Today's 4G is designed for a limited number of UCs

- Throughput-optimized
- Fixed
- Rigid

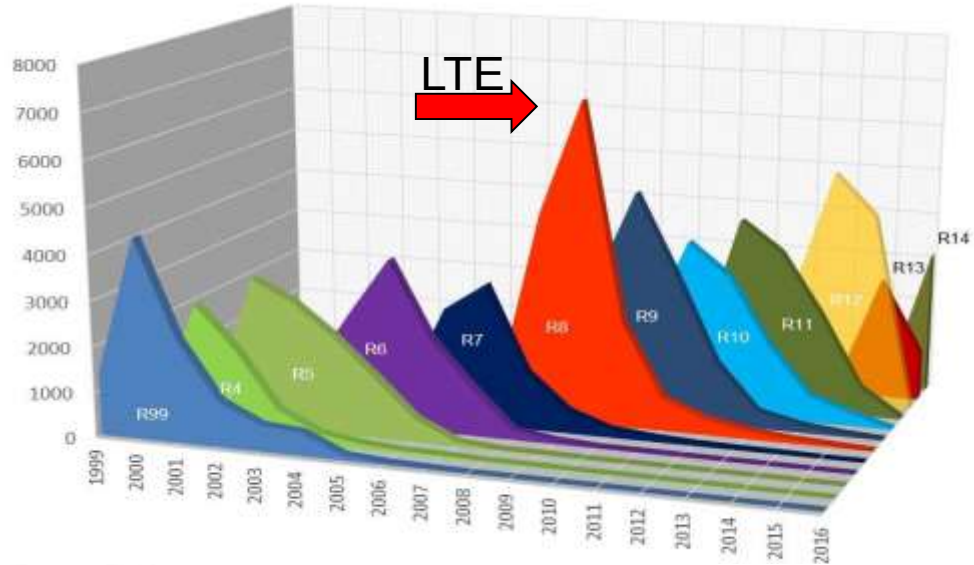


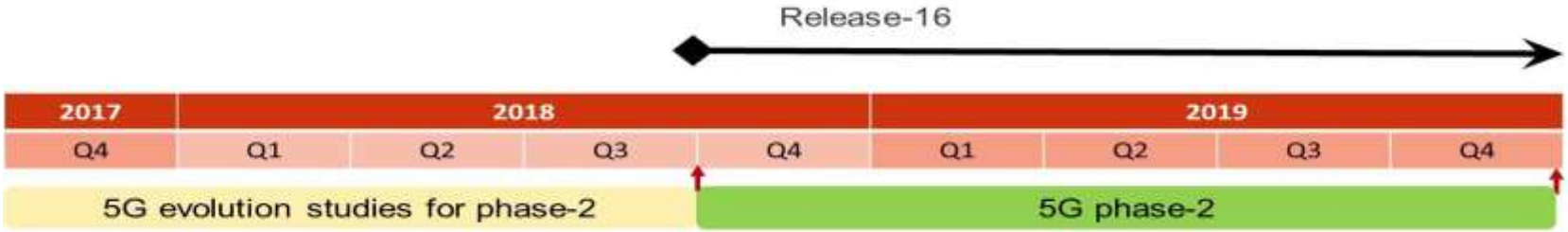
Is 4G enough?

Mindful about

3GPPP facts and figures

514 Companies from 45 Countries
50,000 delegate days per year
40,000 meeting documents per year
1,200 specifications per Release
10,000 change requests per year

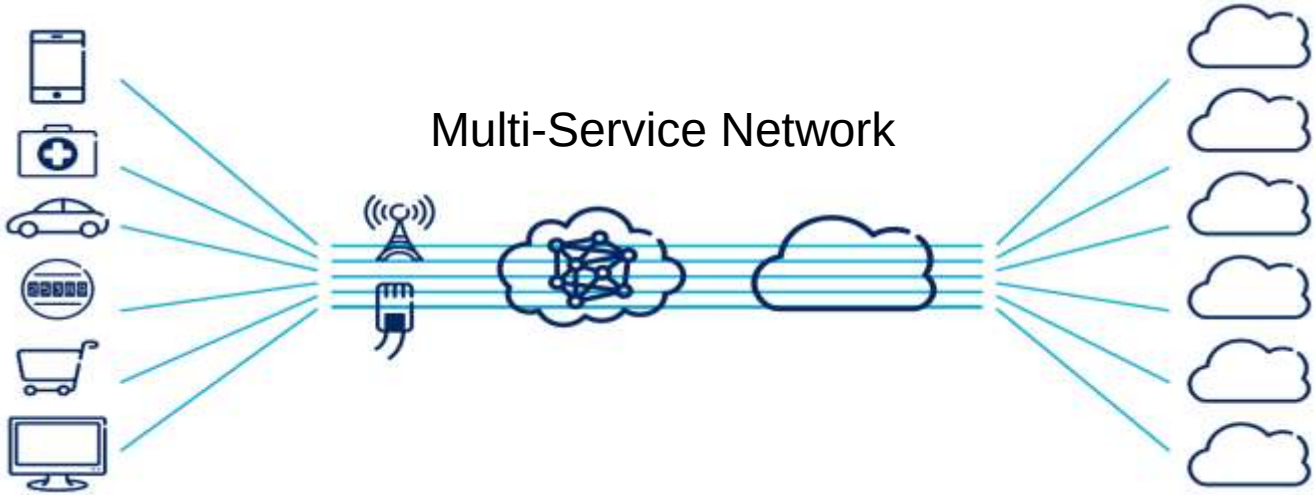




Communication-oriented 4G

Turn physical infrastructure into multiple logical networks, one per service instance: **One-Network, Many-Service**

NOT a one-size fits all architecture **NOT** a Dedicated Network



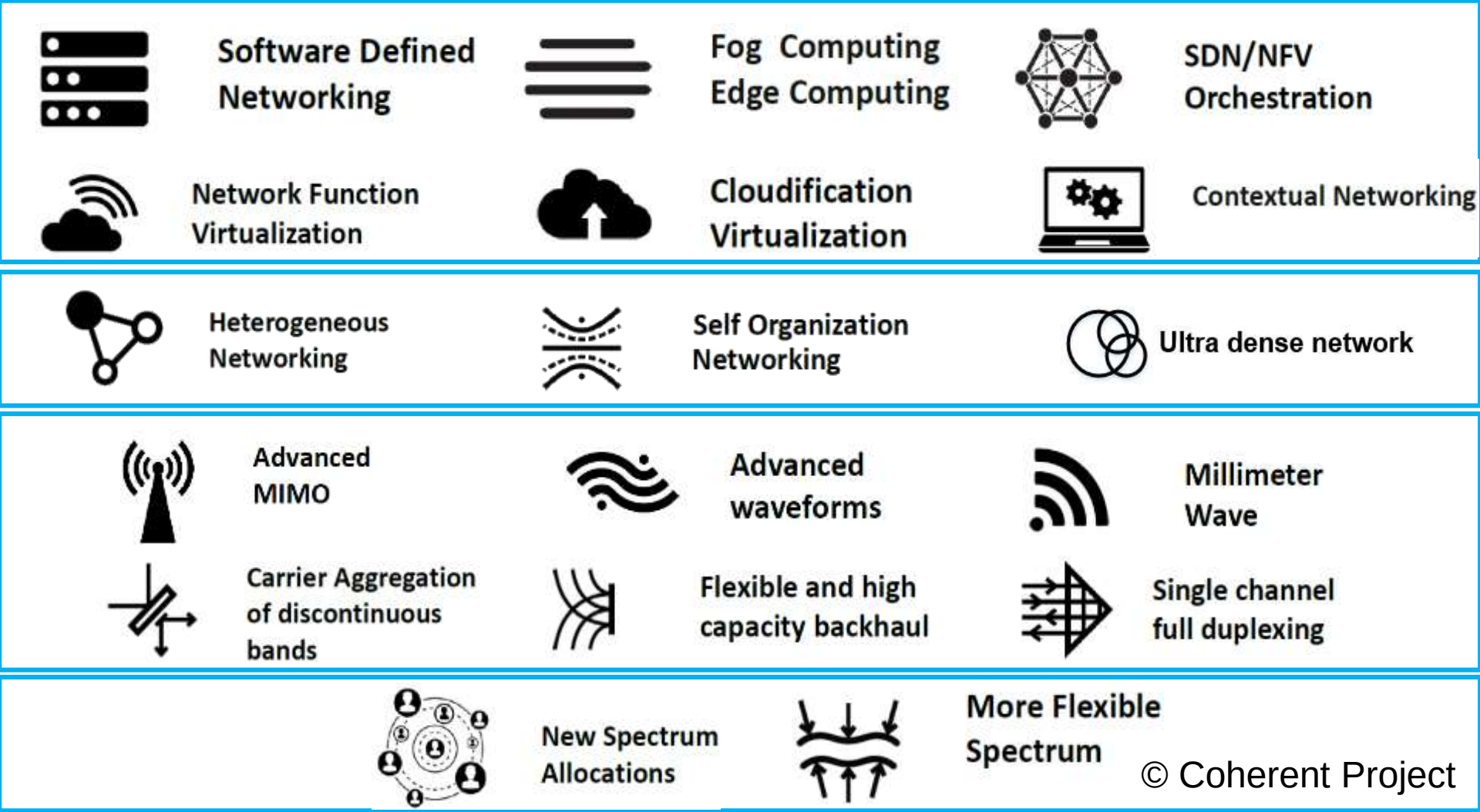
Service-oriented 5G

Different aspects of network slicing have been already prototyped/demonstrated based on Opensource and commercials platforms

Industry is currently providing network slicing by means of
(a) Local/dedicated services enabled by MEC platforms
(b) Dedicated core networks and 3GPP RAN sharing

Next steps : **SO-CN** and **SO-RAN**

From R&D to Reality



5G technology enablers

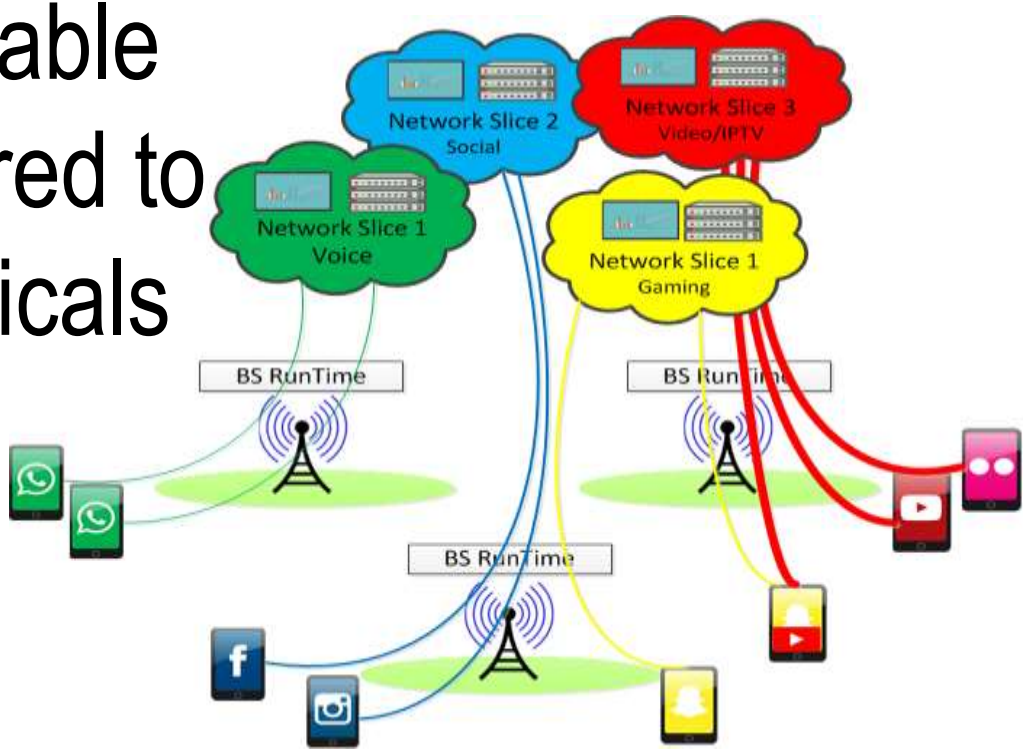
Network Slicing Concept

Flexible & Customizable logical networks tailored to each use-cases/verticals

xMBB

uRLLC

mMTC



Service-oriented 5G

Slicing Technology Enablers

- Softwarization
- Virtualization
- Disaggregation

} Multi-service multi-tenant network

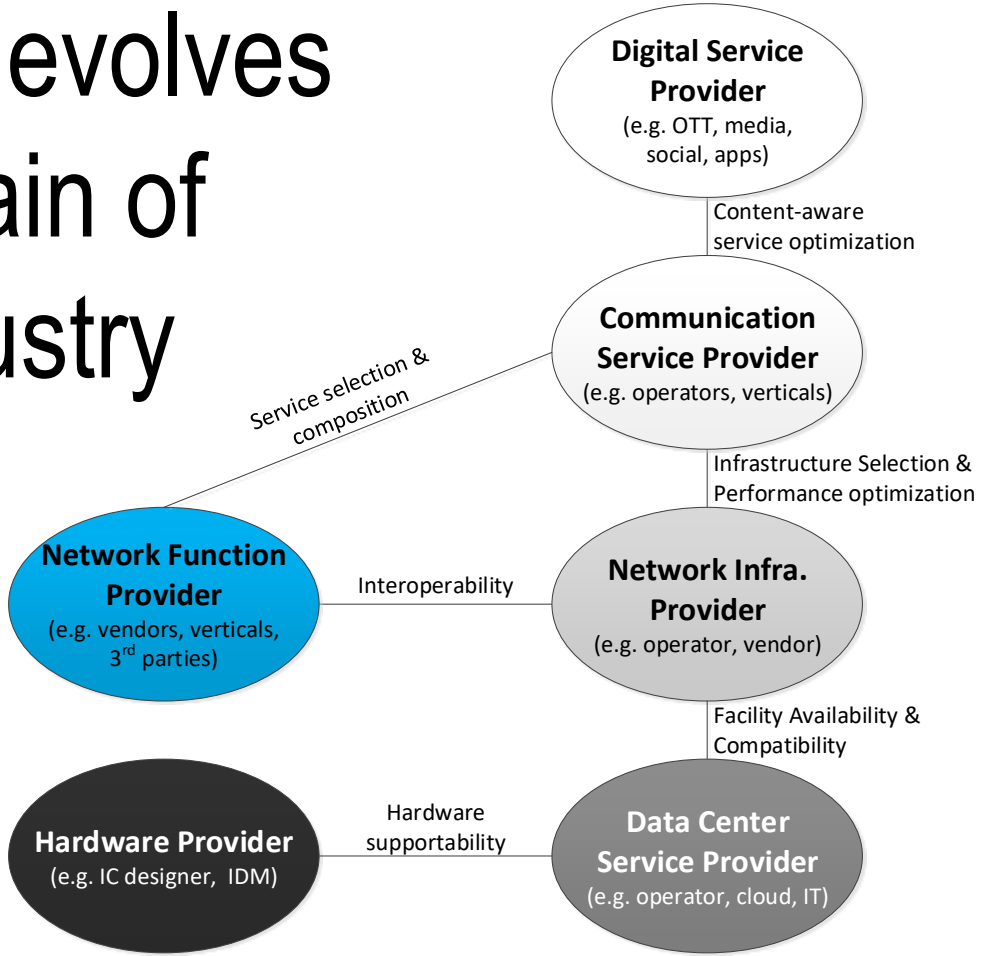
Service-oriented 5G

Why will it happen?

Extreme network flexibility and elasticity

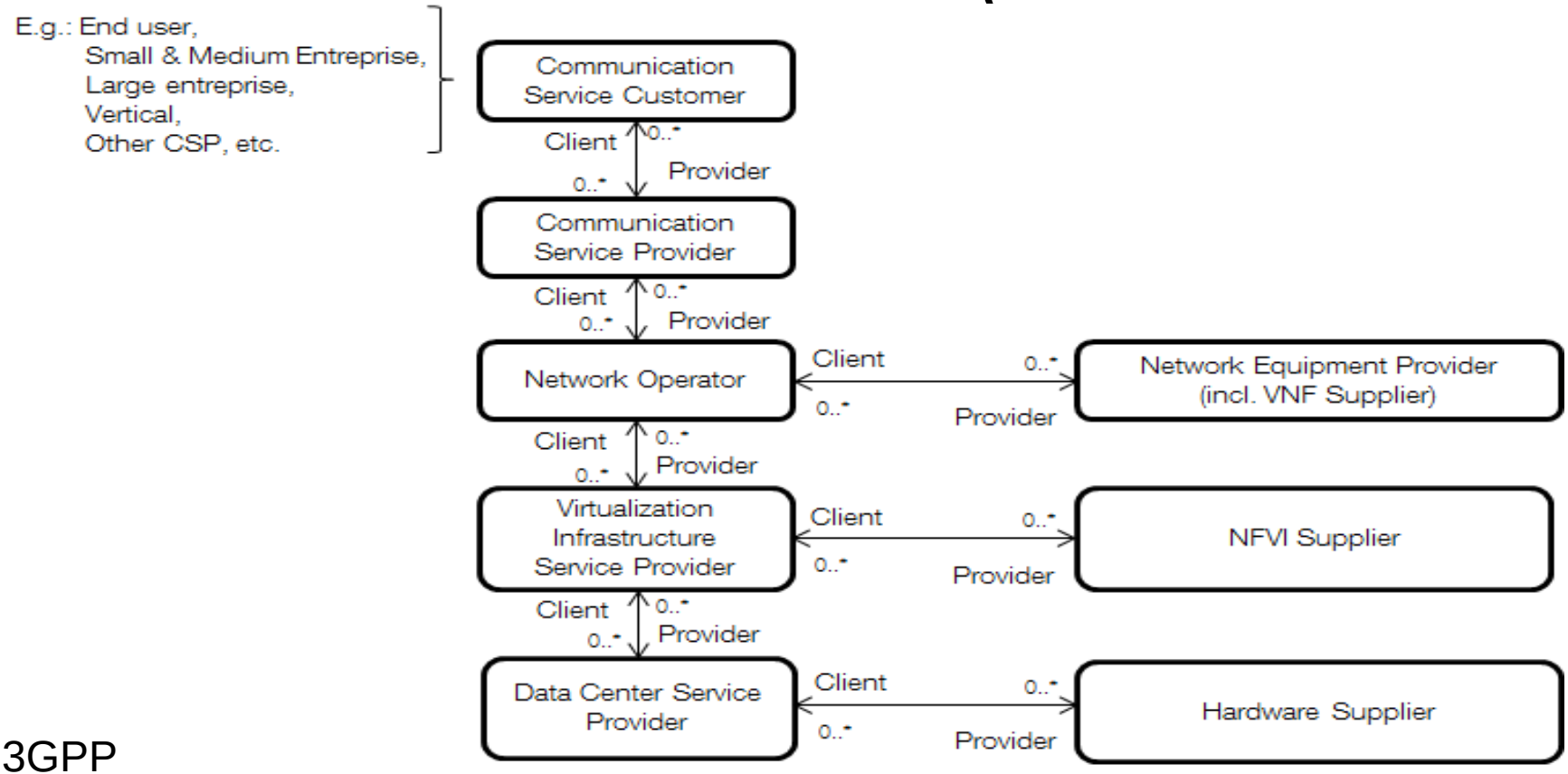
Network Slicing evolves the value-chain of telecom industry

Decoupling of Players, but the reality might be different



Service-oriented 5G

3GPP Role Model (3GPPP 28.801)



Service-oriented 5G

3GPP Re-Architects Mobile Network

	3G	4G	5G
Downlink waveform	CDMA	OFDM	OFDM, SCFDMA
Uplink waveform	CDMA	SCFDMA	OFDMA, SCFDMA
Channel coding	Turbo	Turbo	LDPC (data) / Polar (L1 contr.)
Beamforming	No	Only data	Full support
Spectrum	0.8 – 2.1 GHz	0.4 – 6 GHz	0.4 – 90 GHz
Bandwidth	5 MHz	1.4 – 20 MHz	Up to 100 MHz (400MHz for >6GHz)
Network slicing	No	No	Yes
QoS	Bearer based	Bearer based	Flow based
Small packet support	No	No	Connectionless
In-built cloud support	No	No	Yes

Service-oriented 5G

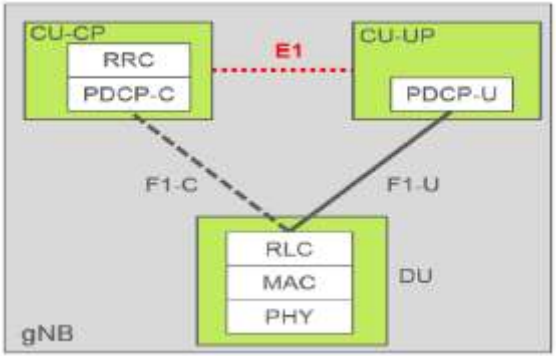
3GPP Re-Architects Mobile Network

3 Tier RAN Node

CU0 → DU[0-n] → RRU[0-m]

Functions Split

CP - UP split

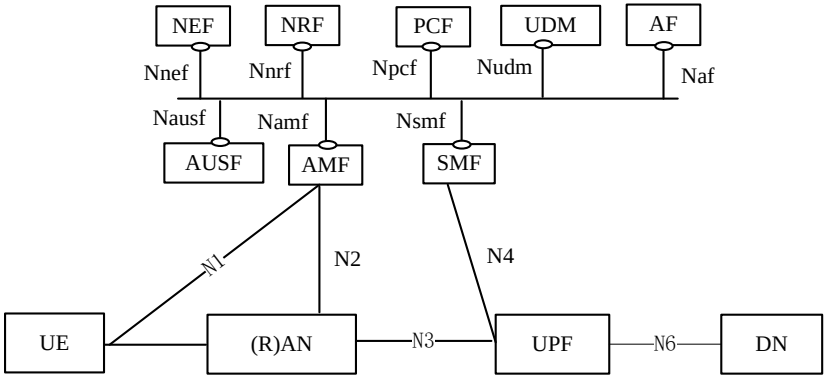


Service-Oriented CN

service catalog and discovery

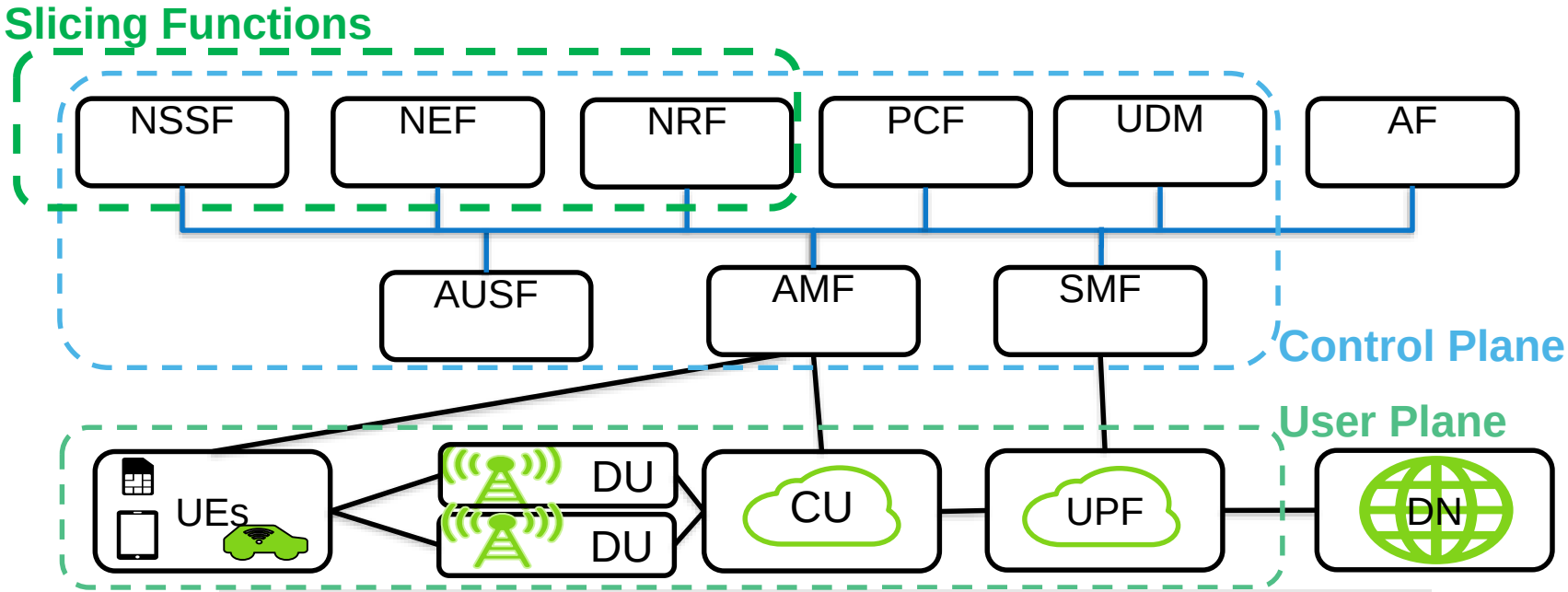
Slice selection function

CP - UP split



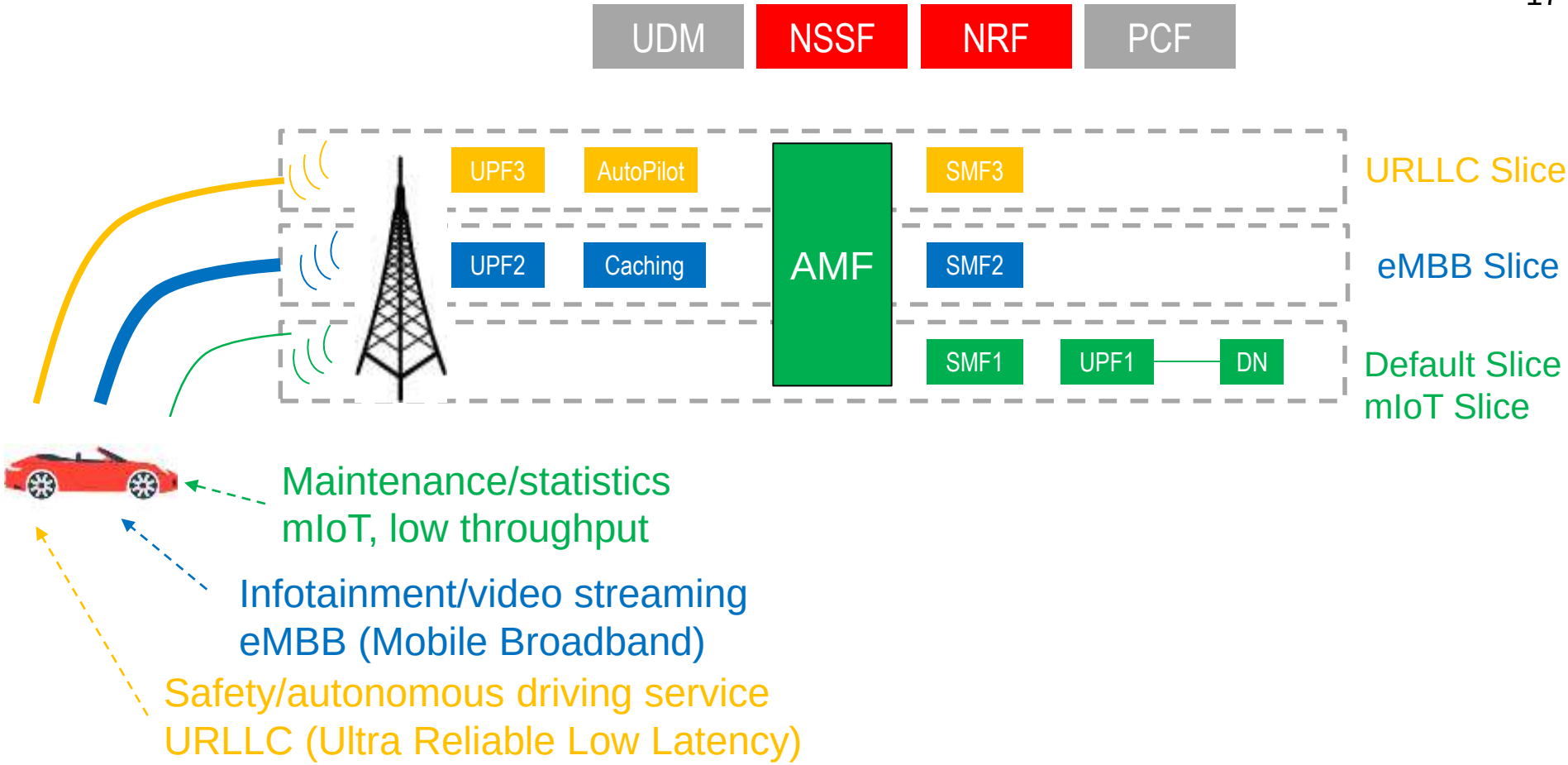
3GPP 5G RAN and CN

3GPP Re-Architects Mobile Network



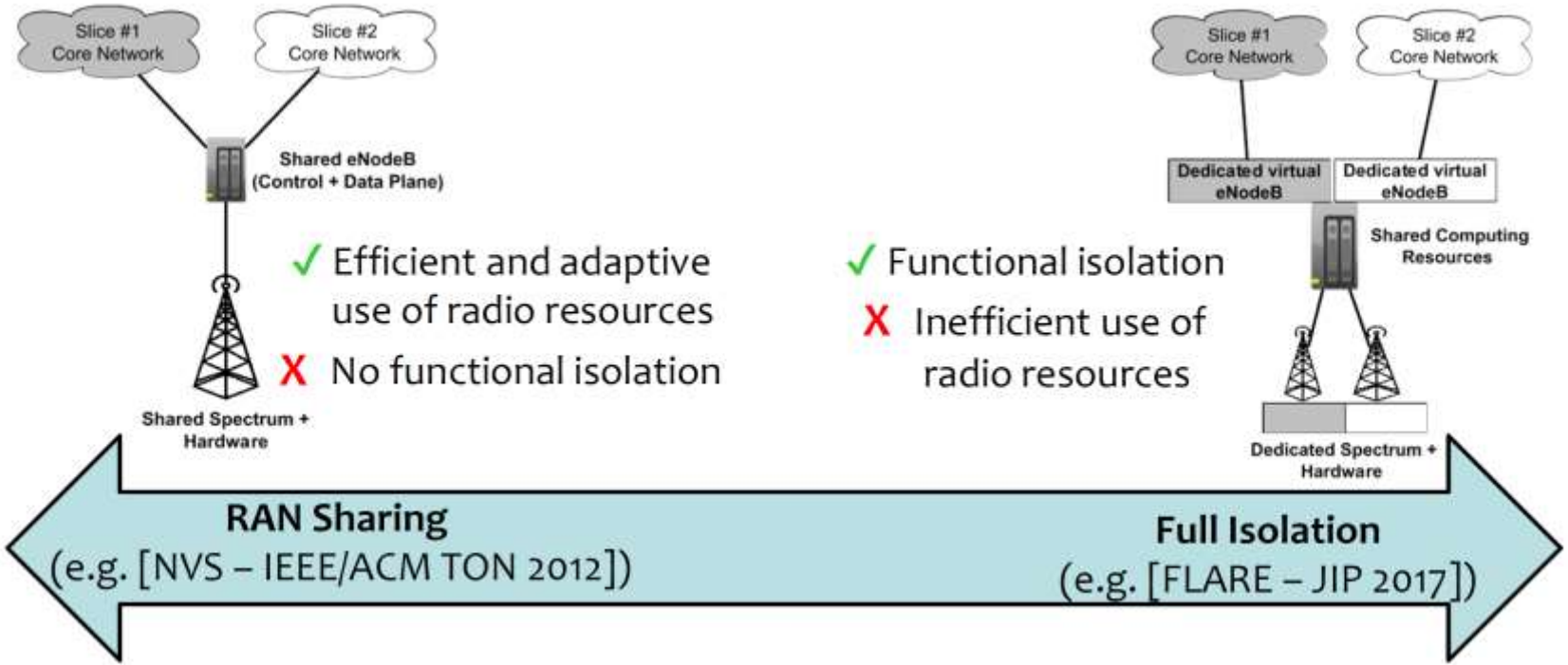
AMF	Access & Mobility Management Function	SMF	Session Management Function
AUSF	Authentication Server Function	UPF	User Plane Function
NRF	Network Repository Function	AF	Application Function
UDM	Unified Data Management	PCF	Policy Control Function
NSSF	Network slice selection function	NEF	Network Exposure Function

3GPP 5G RAN and CN



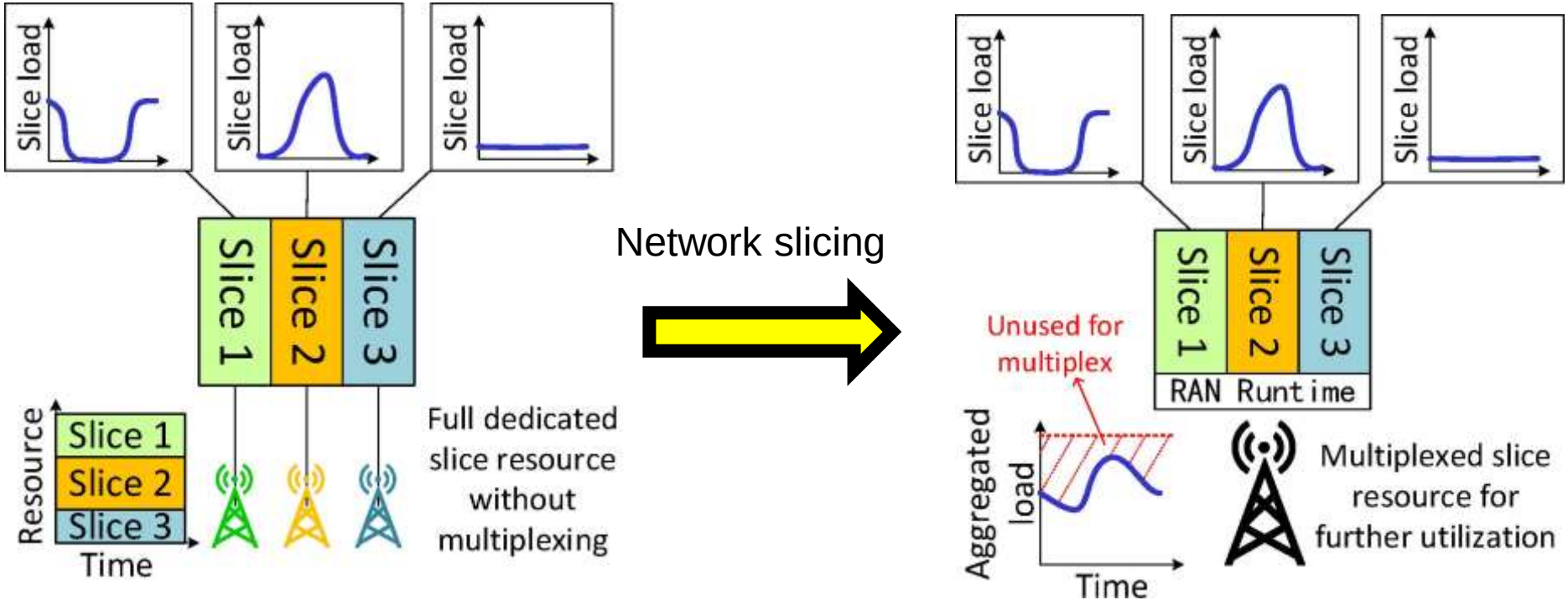
Dedicated or Shared Functions?

Network Slicing



Dedicated or Shared?

Multiplexing Gain



Dedicated or Shared ?

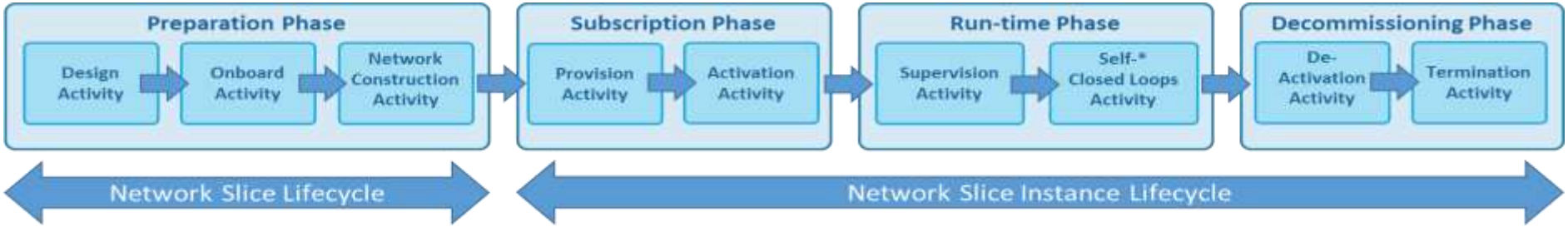
Shared Resources?

Dedicated Resources?

Automation-Orchestration

LifeCycle Management

(Encapsulate Operations)

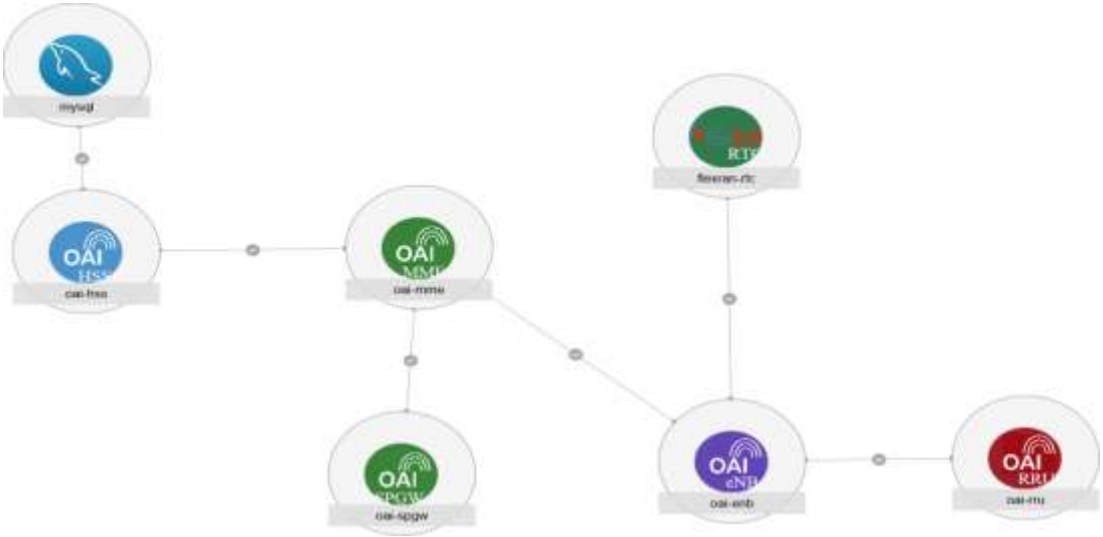


Interplay among control, management, and orchestration subsystems

Automation-Orchestration

LifeCycle Management (Encapsulate operation)

DevOps

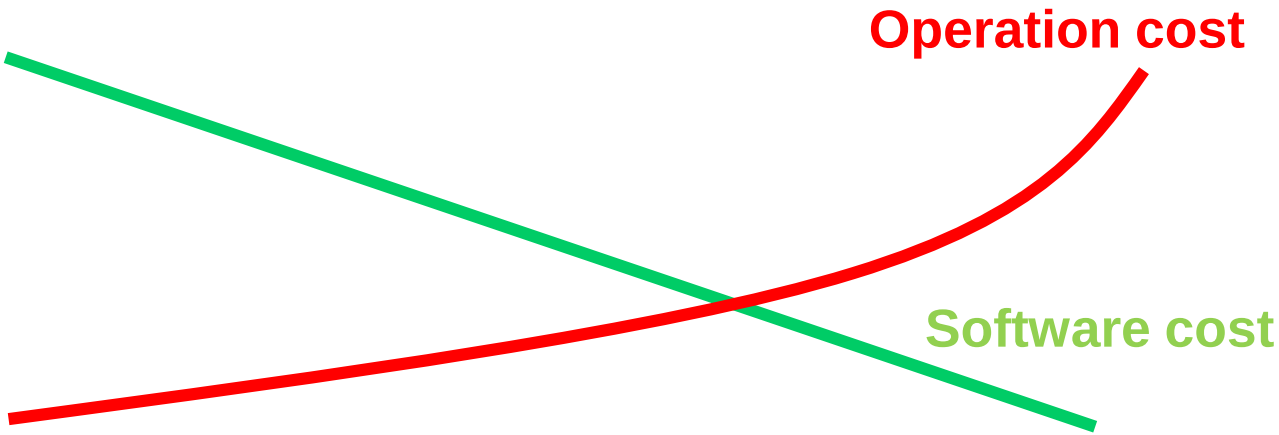


- ➔ installation
- ➔ configuration
- ➔ connections
- ➔ upgrades and updates
- ➔ scale-out and scale-back
- ➔ health checks
- ➔ operational actions
- ➔ benchmarks

https://jujucharms.com/q/oai

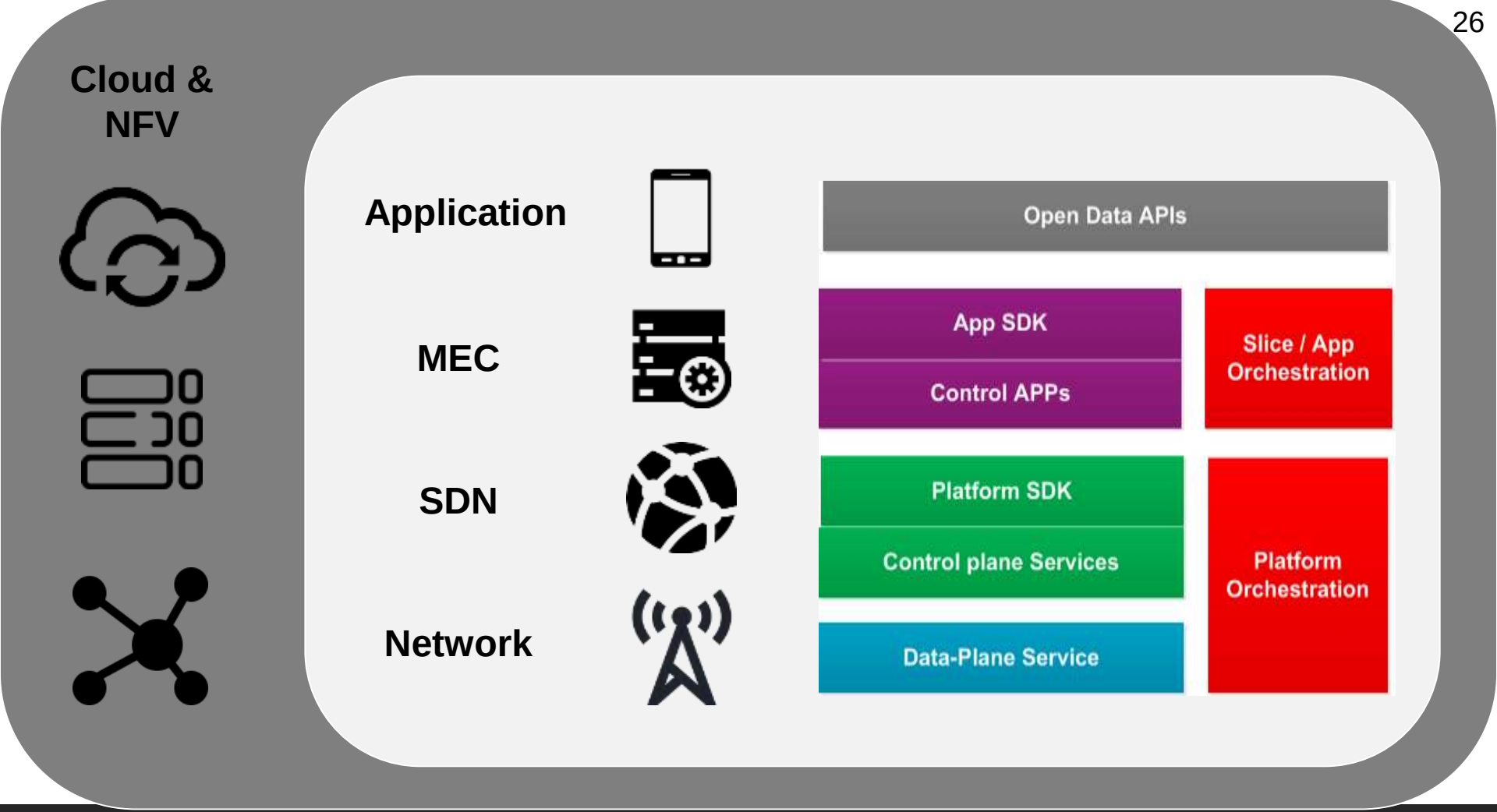
Automation-Orchestration

Phase Change of Modern Software



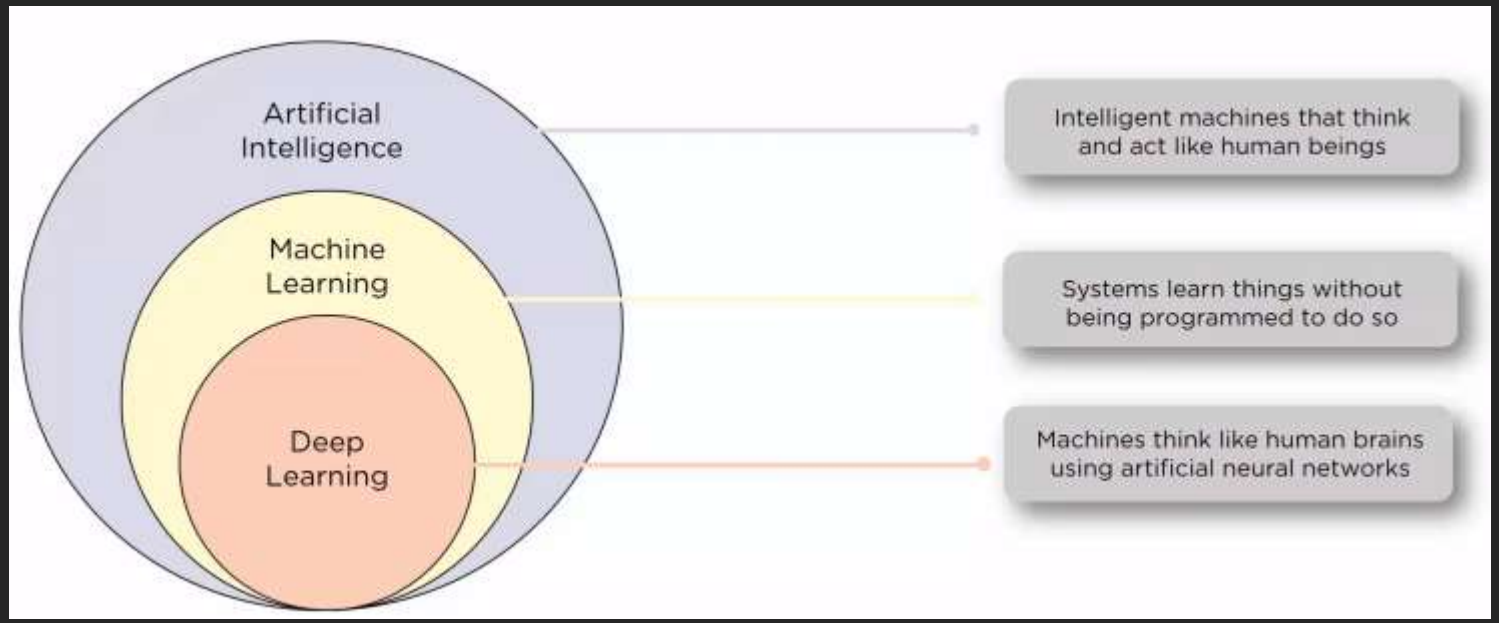
Free software is becoming expensive !

Automation-Orchestration



Network Abstractions and CP-Apps Ecosystems

Data-driven Network Control



Network Slicing brings network flexibility and resource elasticity

(1) Openup the interfaces with the help of SDN

(2) Customized control Apps for monitoring, reconfigurability, and programmability

But, modern networks are too complex to be controlled and optimized by means of rule-based Alg.

Why do we need to evolve 5G?

Flexibility to generalize and comprehend: Never seen Z before, but it is similar to X, so do Y, but adjust as needed

Scale to automate control and management to meet the required QoS/QoE

Dynamicity to constantly adapt and anticipate for different workloads and use cases

Abstraction and multi-layering to combine sources with different semantics

Why do we need to evolve 5G?

MONITOR

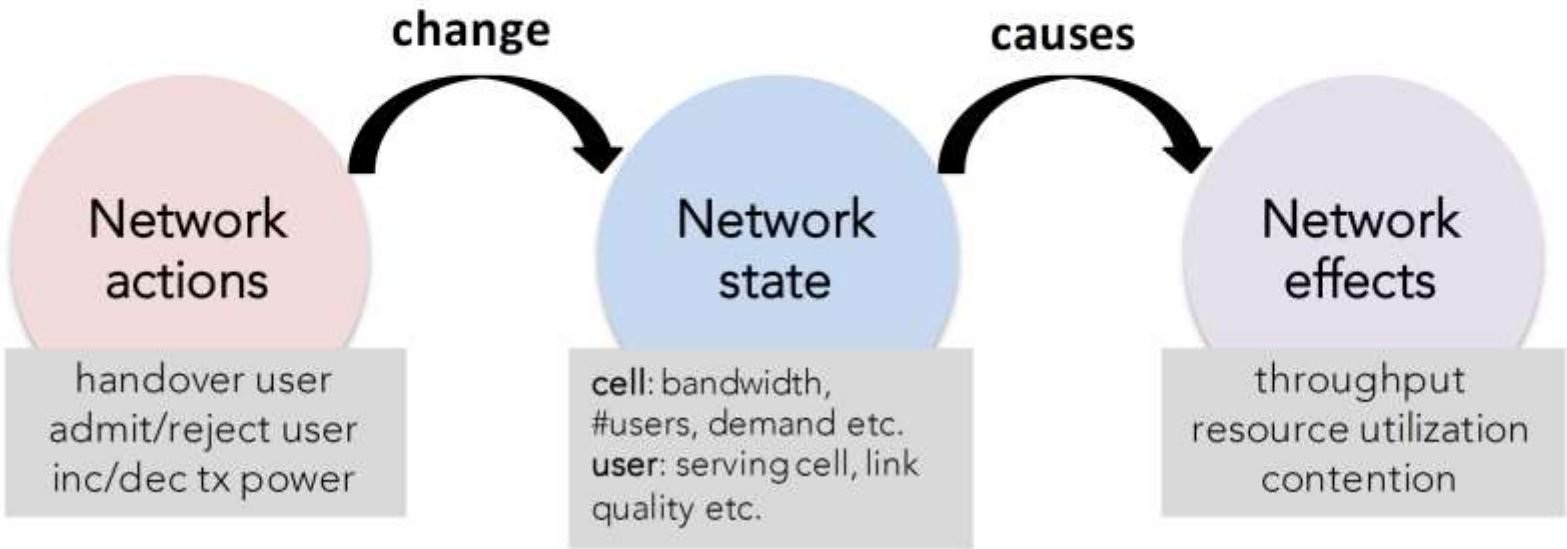
Right now, what is the
avg throughput of user/cell?
resource utilization of user/cell?
contention faced by user/cell?

FORECAST

In the next 1s, what will be the:
avg throughput of user/cell?
resource utilization of user/cell?
contention faced by user/cell?

PREDICT IMPACT

In the next 1s, what if:
handover users?
admit/reject new users?
increase/decrease tx power?



What is Data-driven Control?

ML models to manage network and resources

(a) Comply better with slice SLAs

(b) Maximizes the revenue of physical network operators

(c) Robust against runtime issues

Pipelining by means of

"**Reason-Predict-Control**"

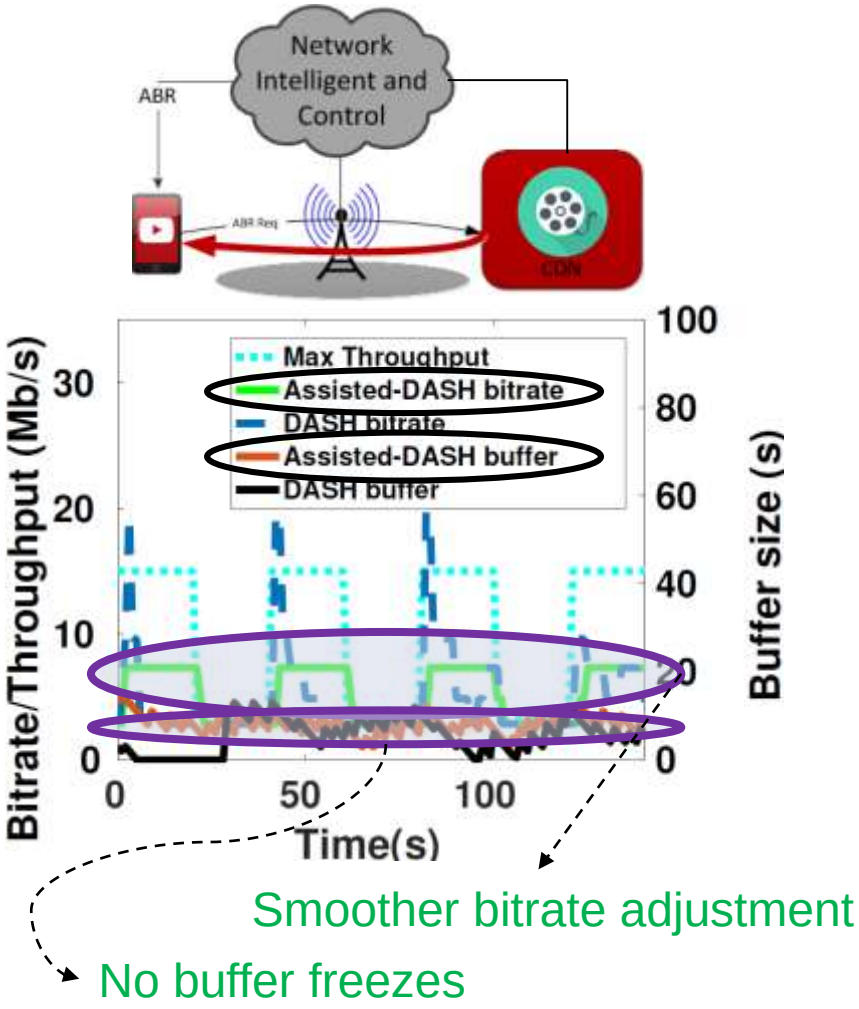
Why Data-driven Network Control?

Need to predict the **user and network performances in time and space** with many **unknown and/or dynamic** variables

(1) Realtime control and coordination across cells

(2) Network Intelligence

Data-Driven Control



Objective:

maximize video quality

minimize stall time

Maintain service continuity

Policy:

maintain SLA (e.g. minimum average throughput)

Data:

Link quality

sustainable TCP throughput

Control (beyond just ABR, joint UE and BS):

1. Adapt the video bit rate through video optimizer

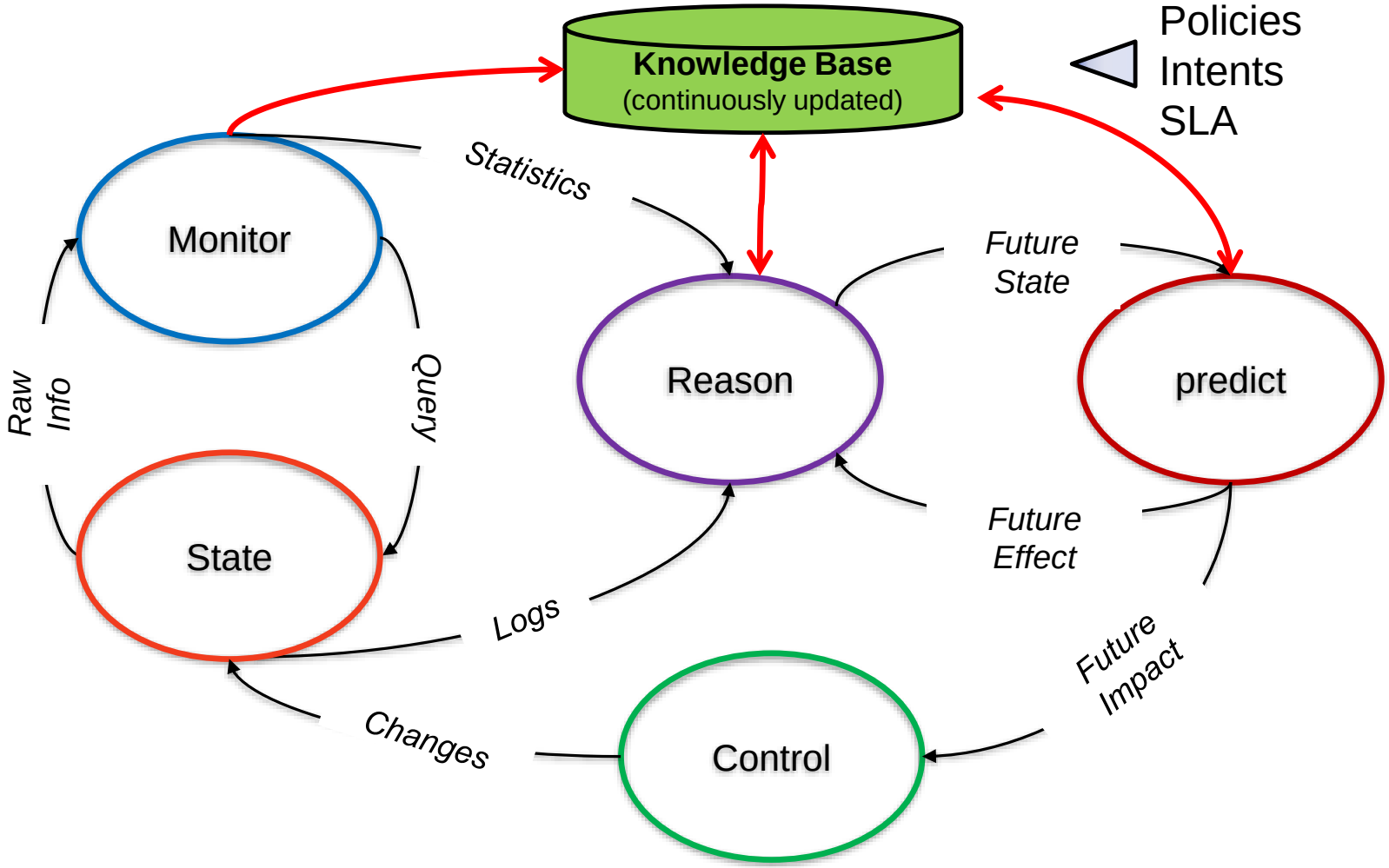
2.1 Add/provision a new BS through SMA+ORCH

2.2 increase the BW of the current BS (SMA)

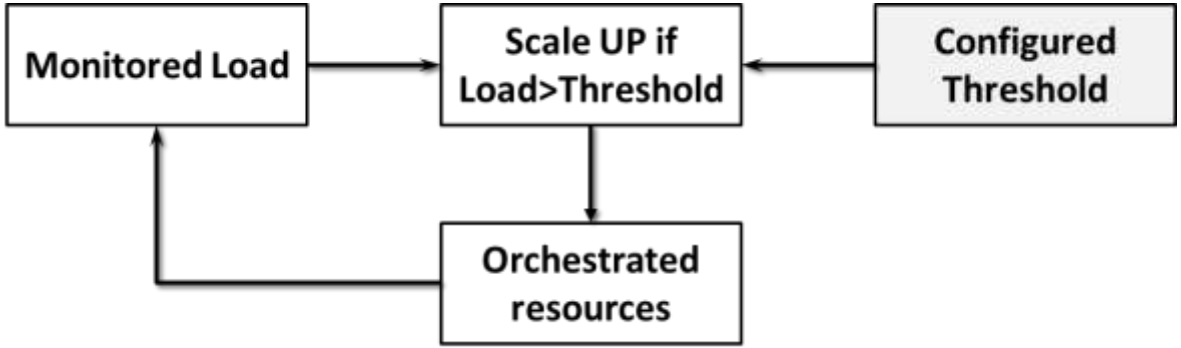
3. Interference coordination through RRM

4. Update frequency and power through SMA

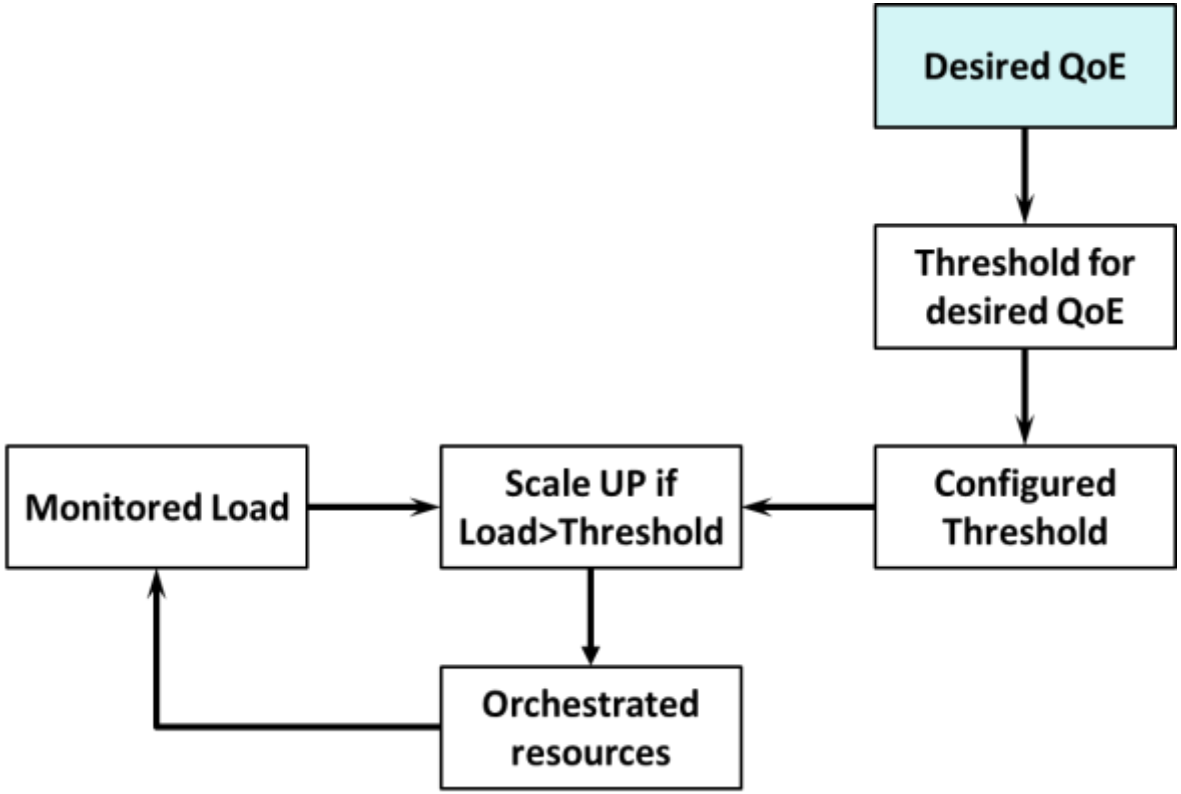
Video Streaming Use-Case Revisited



Proactive Control Scheme



Example of QoE With PCS



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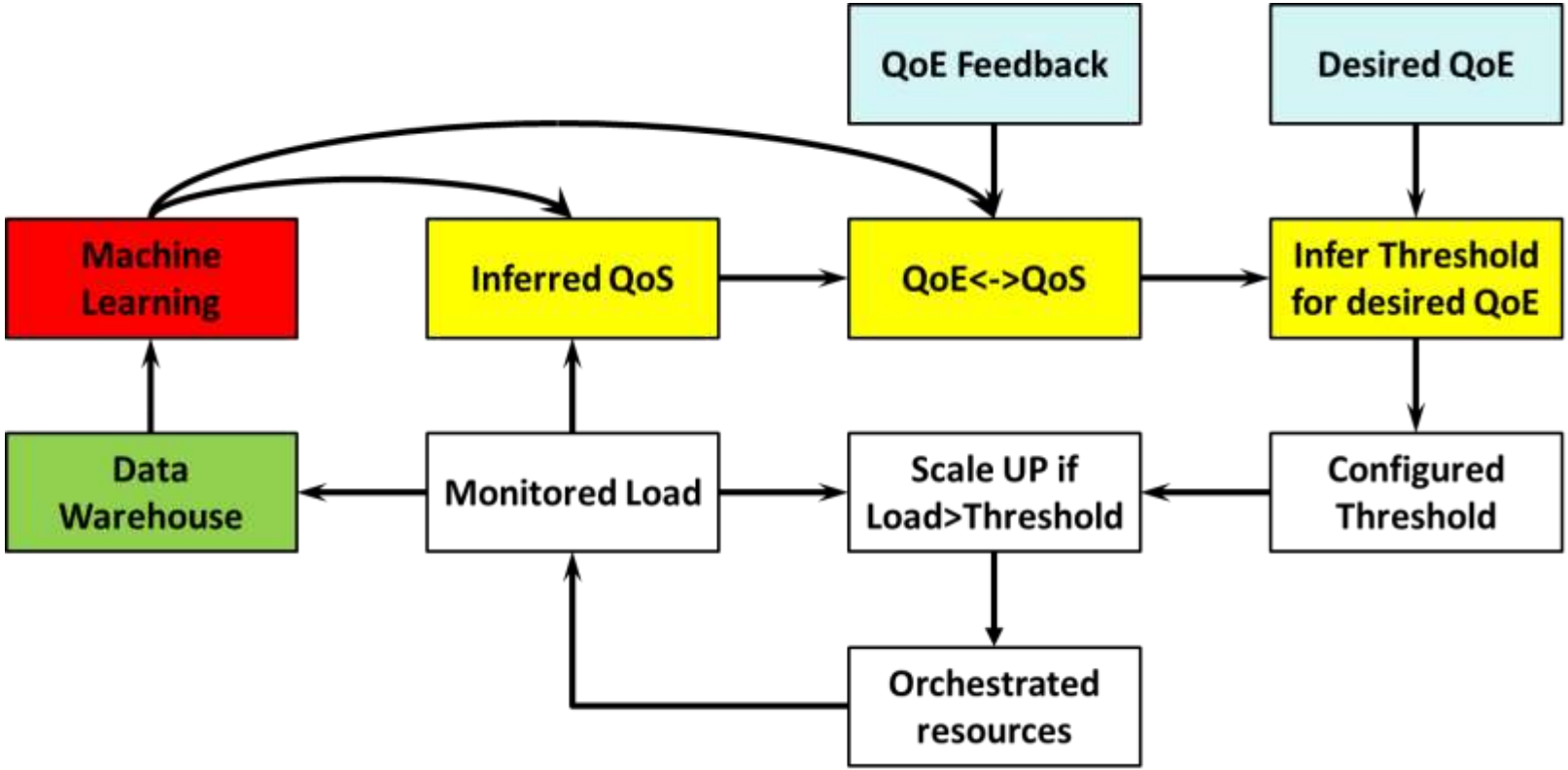

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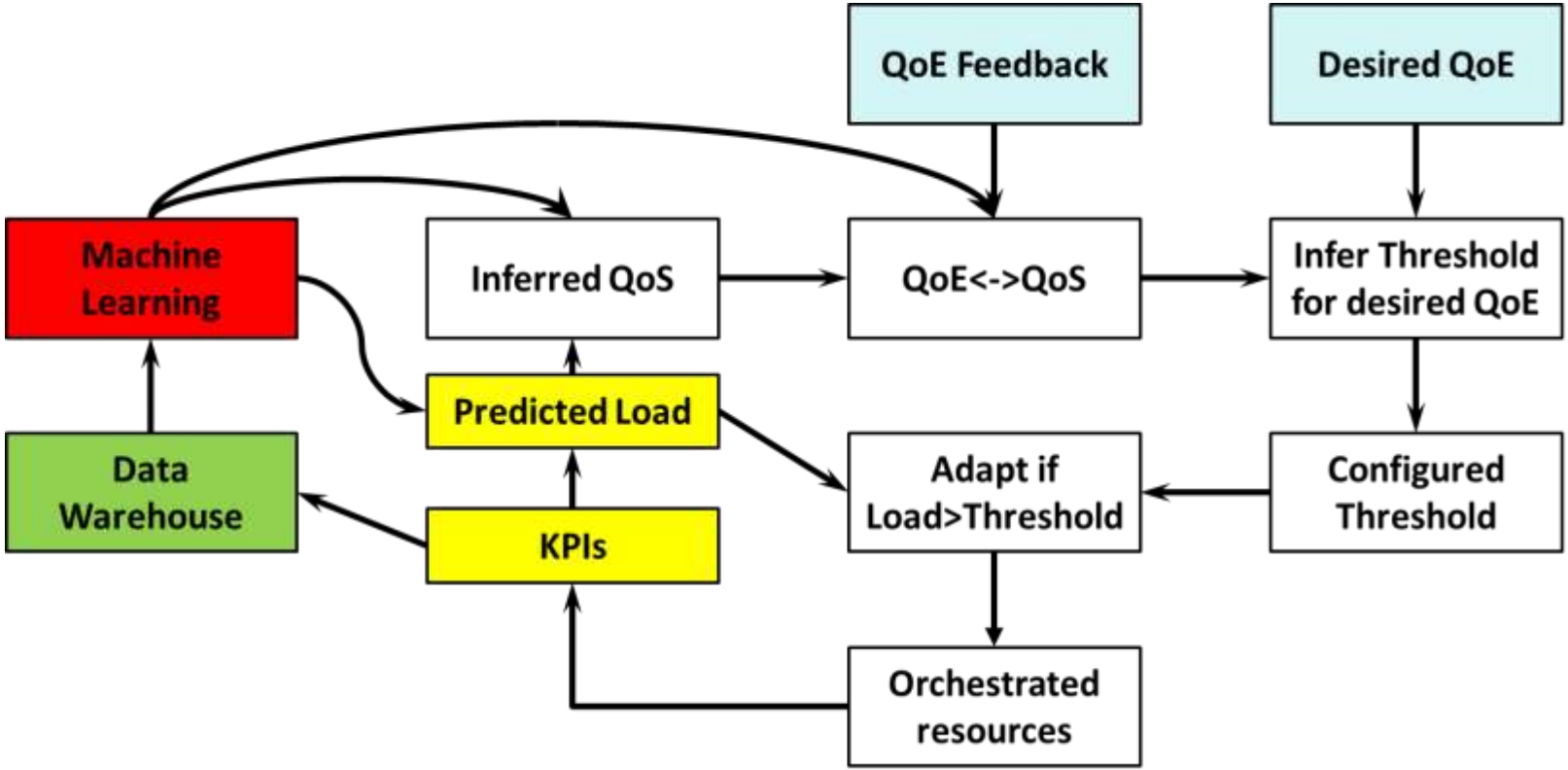

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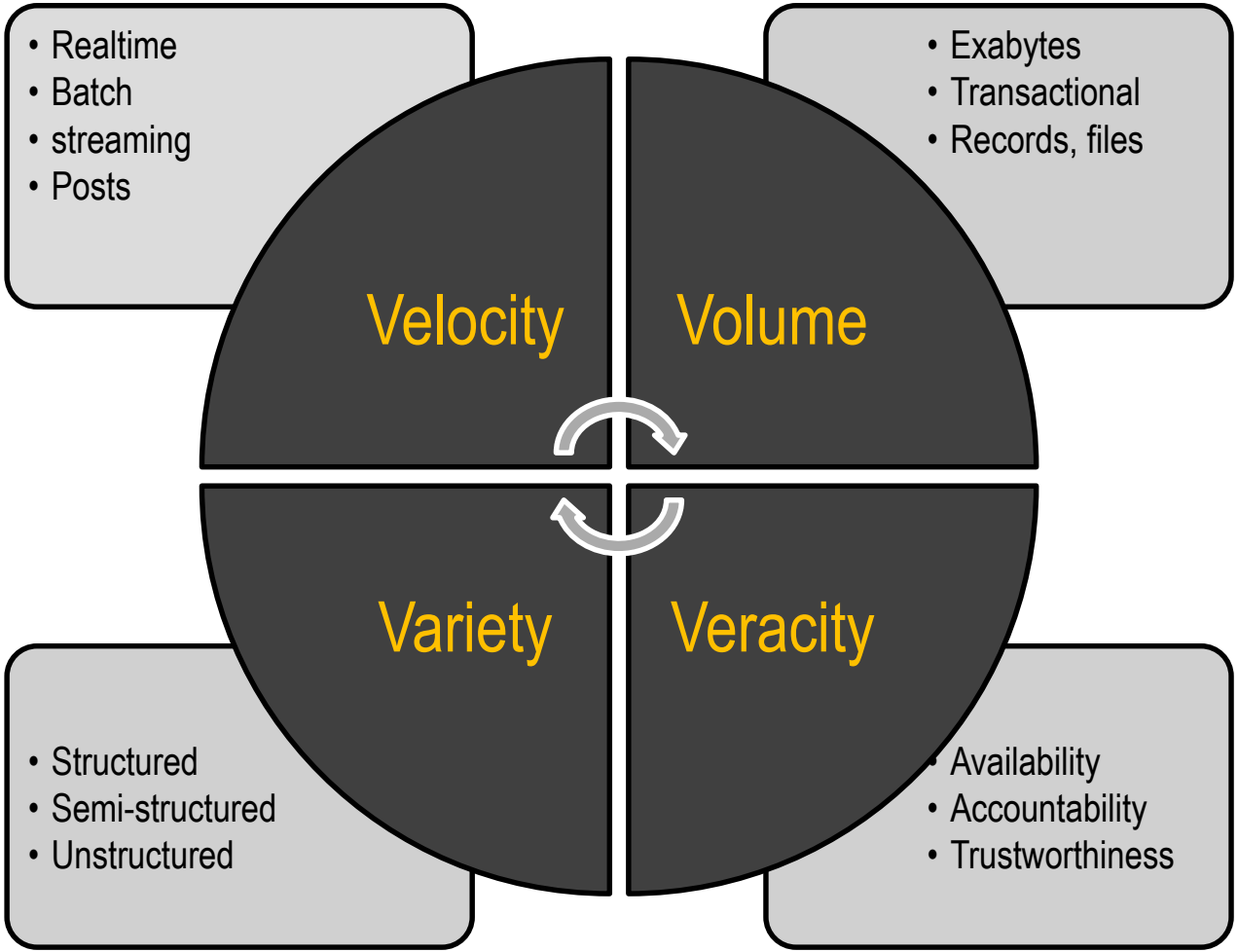

Characterizing the Data

Conclusion

Fusion of Computing, Information and Cellular technologies

(a) 5G and beyond is not only New Radio and verticals, it is also an evolution in General-Purpose computing for wireless networks

(b) More and more software technologies (NFV,SDN,MEC) and Data (mining, analytics) jointly with radio signal processing

Conclusion

Network slicing is an on-going research with several challenges

Isolation, **Sharing**, **Customization**

Satisfy requirements of slice owner and operator/infra. provider

Conclusion

Data-driven network control is difficult

Reason-Predict-Control is a generic framework

Prediction performance is limited by the available computing resources

Conclusion

(1) Can we predict user QoS/QoE per application in realtime?

(2) Can we learn network-user-application dependencies across various network domains?

(3) Can we automatically learn the right control to apply?

Open Questions


Q
A

Personal Info:

Email: navid.nikaein@eurecom.fr

Website: http://www.eurecom.fr/~nikaeinn/

Linkedin: https://www.linkedin.com/in/navidnikaein

Tel: +33.(0)4.93.00.82.11

Mosaic-5G.io :

Mail : contact@mosaic-5g.io

Website : http://mosaic-5g.io

Linkedin: https://www.linkedin.com/in/mosaic-5g

Twitter: @mosaic5g

Contact Information