5GaaL: 5G as a LEGO

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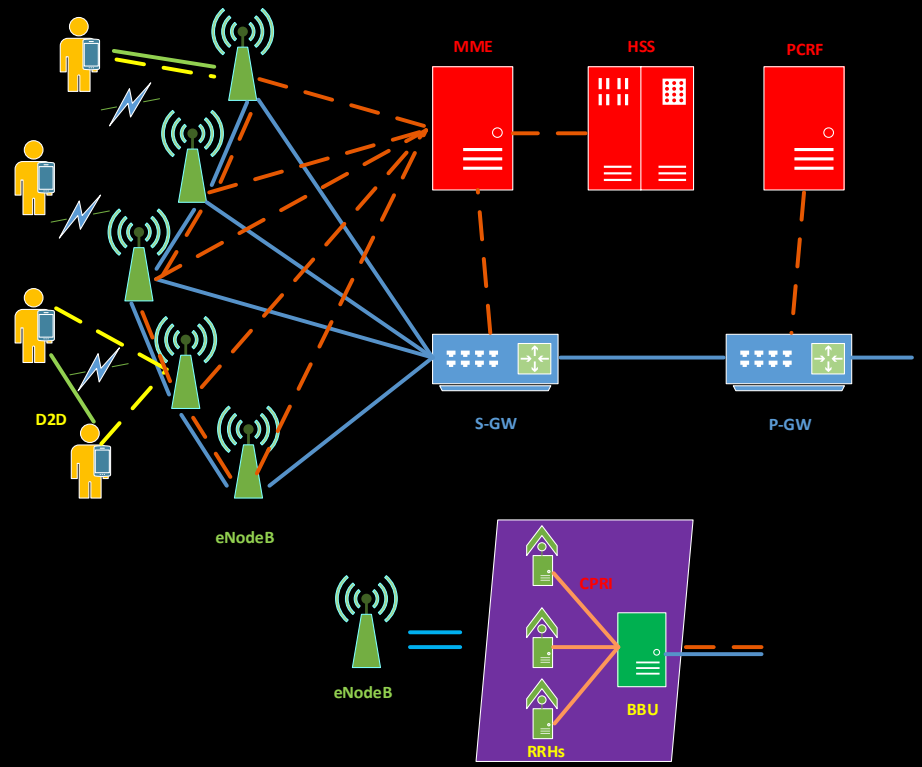
Introduction

- What we got (4G)
- What we want to achieve (5G)
- Which tools we want to use for 5G
- Which concepts do we have (C-RAN, 5G PPP architecture)
- Important problems that we are facing
- 5G based on abstractions, i.e. 5G as a LEGO
- Final remarks

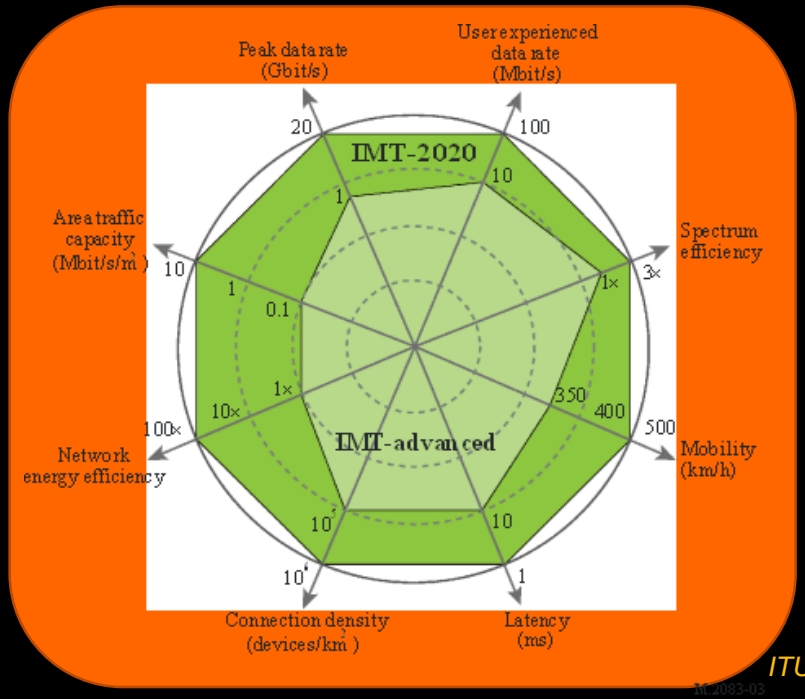
Starting point: LTE-A



- Low delay (<10 ms), high bitrate (1.2/0.6 Gbps)
- Flexible radio channels width, carrier aggregation
- Simple architecture, All-IP interfaces and protocols
- Separation of control and data planes in Core
- RAN to certain extent decentralized (X2, D2D)
- RAN management automated (SON)
- No application level services (focus on connectivity)
- The fastest deploying mobile technology ever (low CAPEX)

Still evolving R10, R11, R12, R13 (MTC, D2D, relays, eICIC ….) - can be ‚softwarized’

5G requirements



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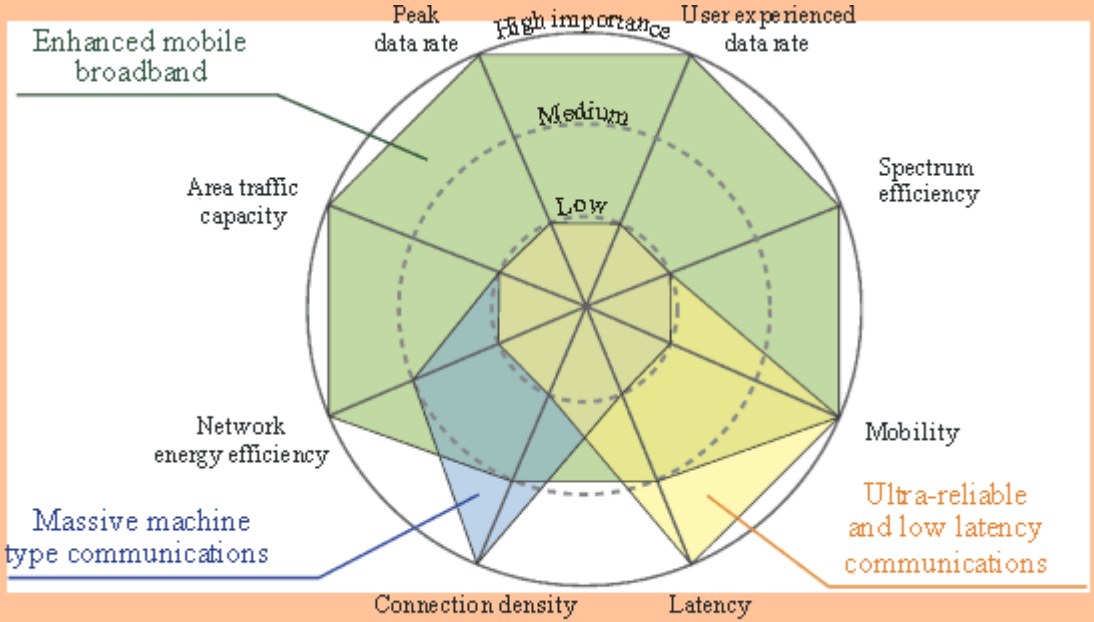
Many requirements already formulated: NGMN, ITU-R, 5G PPP

- Low latency
- High reliability for MTC
- Energy efficiency
- High connection density
- Spectral efficiency
- High traffic capacity
- One click service deployment

Cost of 5G can be very high

- In order to cope with reliability requirements a redundant network is required
- In order to cope with high traffic capacity we have to use high frequencies and dense radio network

5G requirements (use case oriented)



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Not all parameters for a specific use case are of equal importance!

- Can we use multiple RATs of different performance instead of designing an omni-potential RAT? If so we should define some service categories combined with the requirements
- Multiple RATs should be logically separable and combined with (in some cases) multiple Core networks to provide e2e connectivity
- Such approach may lead to multiple parallel networks (should I say 5G slices?)

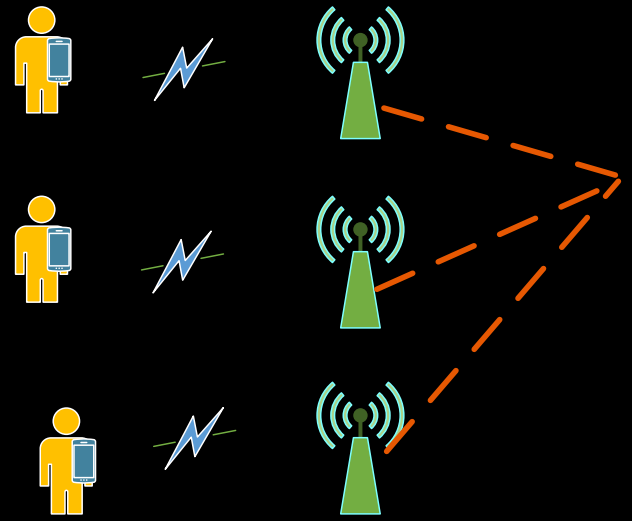
Tools: 5G key technologies

Tool	Properties
SDR	Implementation of radio PHY in software, excellent flexibility, performance issues
SDN	Separation of logically centralized control plane from the data plane. Control plane programmability from scratch, flow oriented operations, easy network virtualization
Clouds	Efficient aggregation of computing and storage resources, virtualization
NFV	A framework for management of software modules in a distributed environment
Orchestration	Not clearly defined term (except NFV and clouds): the ability for fast reconfiguration of network for a specific purpose in a multi-domain environment, related to one-click service deployment
Network slicing	[ITU-T Y.3011], [ITUT Y.3012]. Slicing allows logically isolated network partitions (LINP) with a slice being considered as a unit of programmable resources such as network, computation and storage. [3GPP TR 22.891] A slice is composed of a collection of logical network functions that supports the communication service requirements of particular use case(s). The network slicing primarily targets a partition of the core network, but it is not excluded that RAN may need specific functionality to support multiple slices or even partitioning of resources for different network slices.

These technologies are not 5G specific and so far not widely deployed yet (except of SDR and Clouds)

Radio solutions are becoming more and more complex

- MIMO
- Beamforming
- eICIC
- CoMP
- NOMA
- Network coding
- Cognitive radio

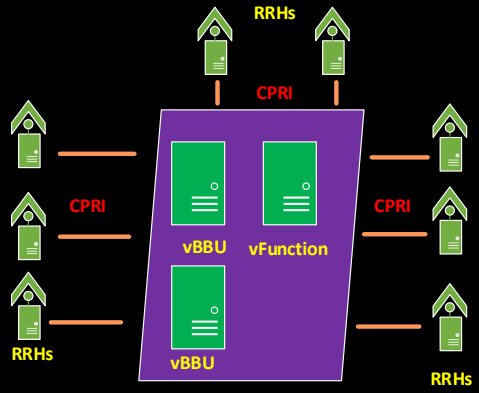


No more single node only oriented operations!

C-RAN

Reasons to like C-RAN:

- Excellent flexibility, easy upgrade (SDR)
- Simple RRHs, easy management
- Fast handover (centralized operations, no RTT problem)
- Resources aggregated, reusable
- Easy, centralized optimization of resources
- Easy coordination: CoMP, eICIC
- Green solution



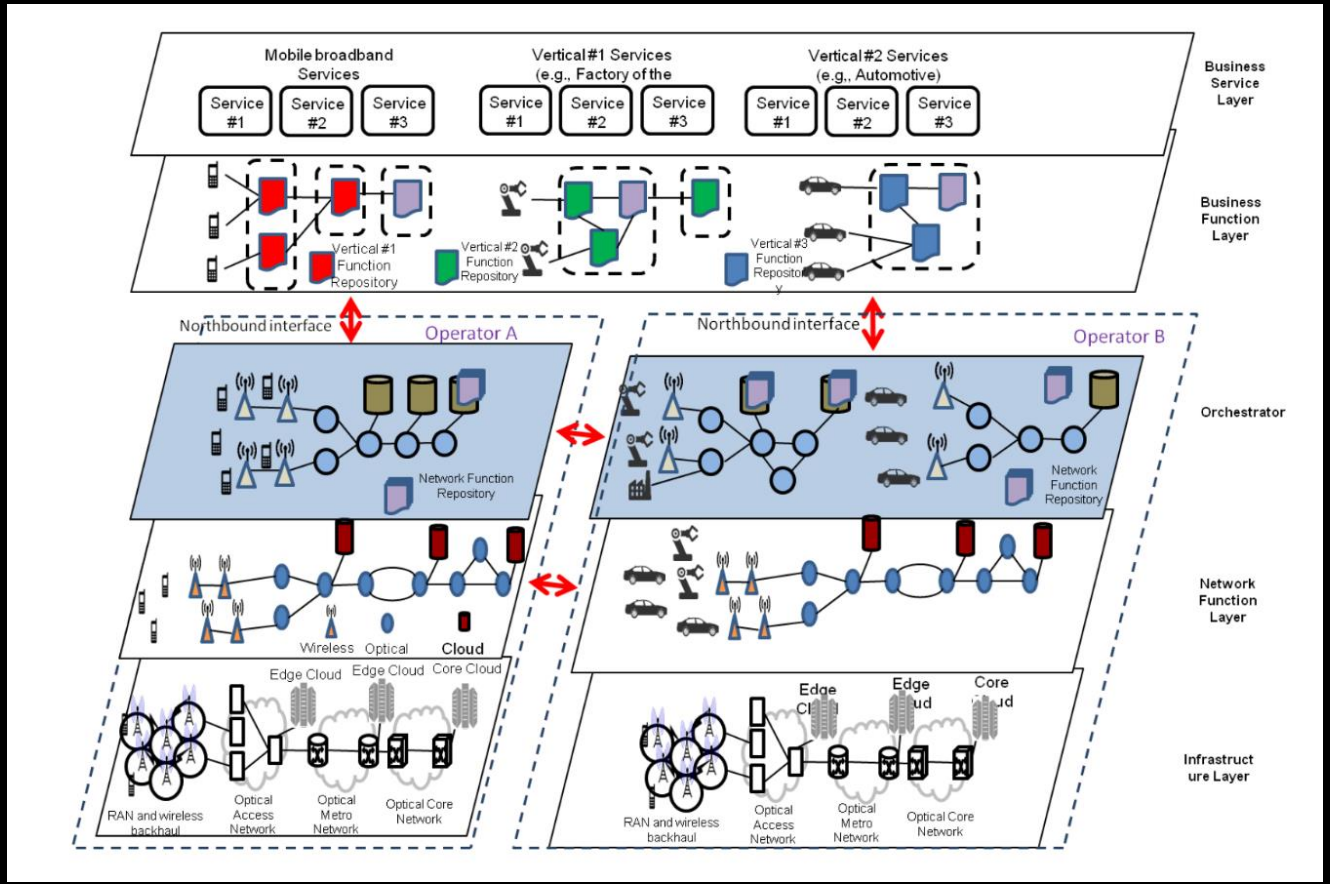
C-RAN has CPRI related problems:

- Inefficient transport of I/Q samples
- CPRI(20 MHz LTE, 4x2 MIMO, 3 sectors) = 16.6 GBps
- Star-like topology
- Limited range (40 km)
- Low latency (0.1 ms) and low jitter is required
- Dark fiber or lambda required
- CBR bitstream, usage independent

The work on RRH-BBU improved transport is ongoing: NGFI, SDAI, OBSAI, ORI

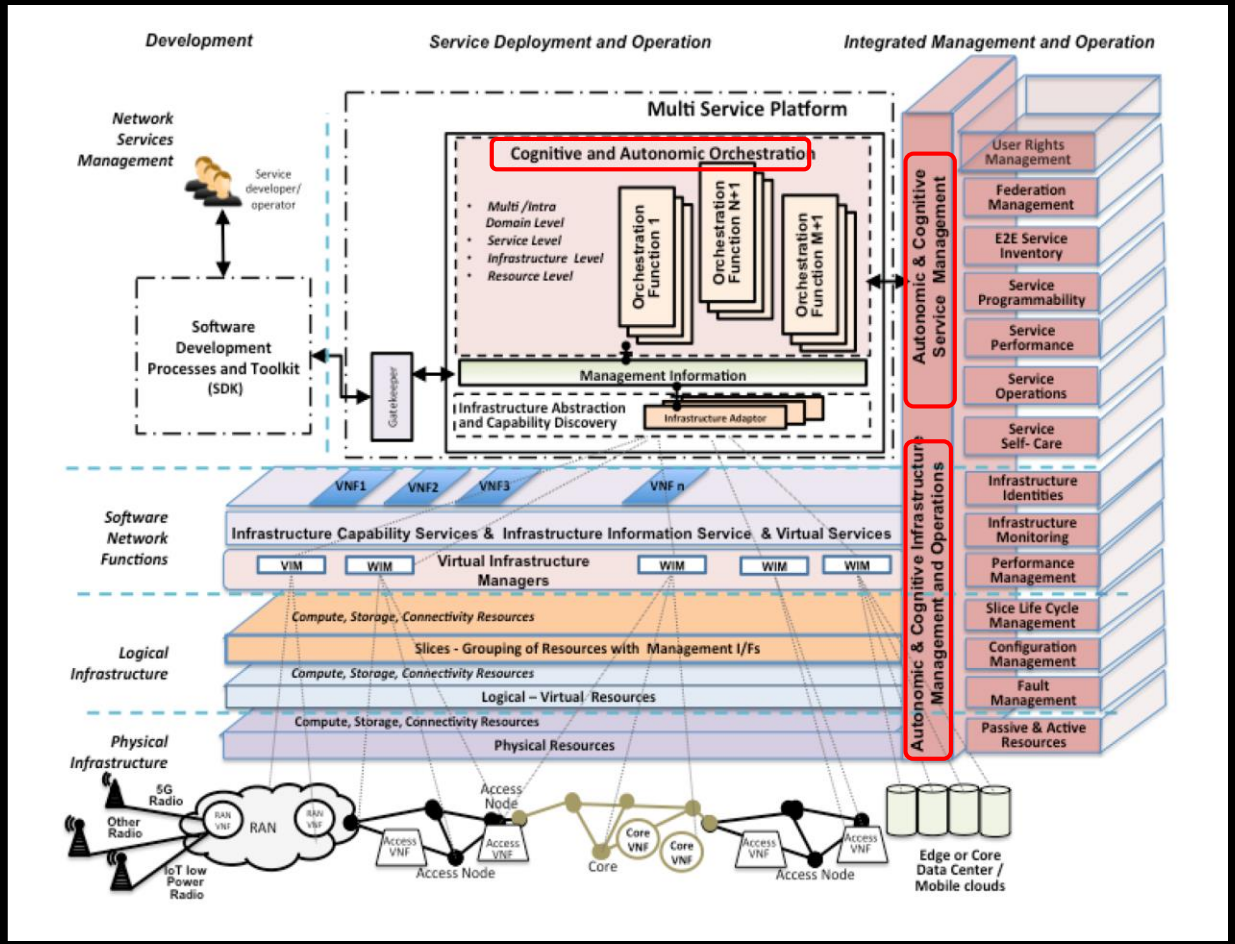
DWDM capabilities:
10 Gbps/lambda
100 x lambda/fiber
700-800 fibers/cable

5G PPP: 5G Ecosystem



5G PPP

5G PPP: 5G Service/Infrastructure/Management/Orchestration Arch.



It looks like generic FN approach

Doesn't look simple ☹

Cognitive and Autonomic Orchestration/Management/ Operations means:

- Monitoring of network/services
- Taking dynamically some decisions

It leads to feedback loop based decisions that may cause unstable network behavior. We will have multiple feedback loops, multi-objective optimization in a distributed environment. Troublesome.

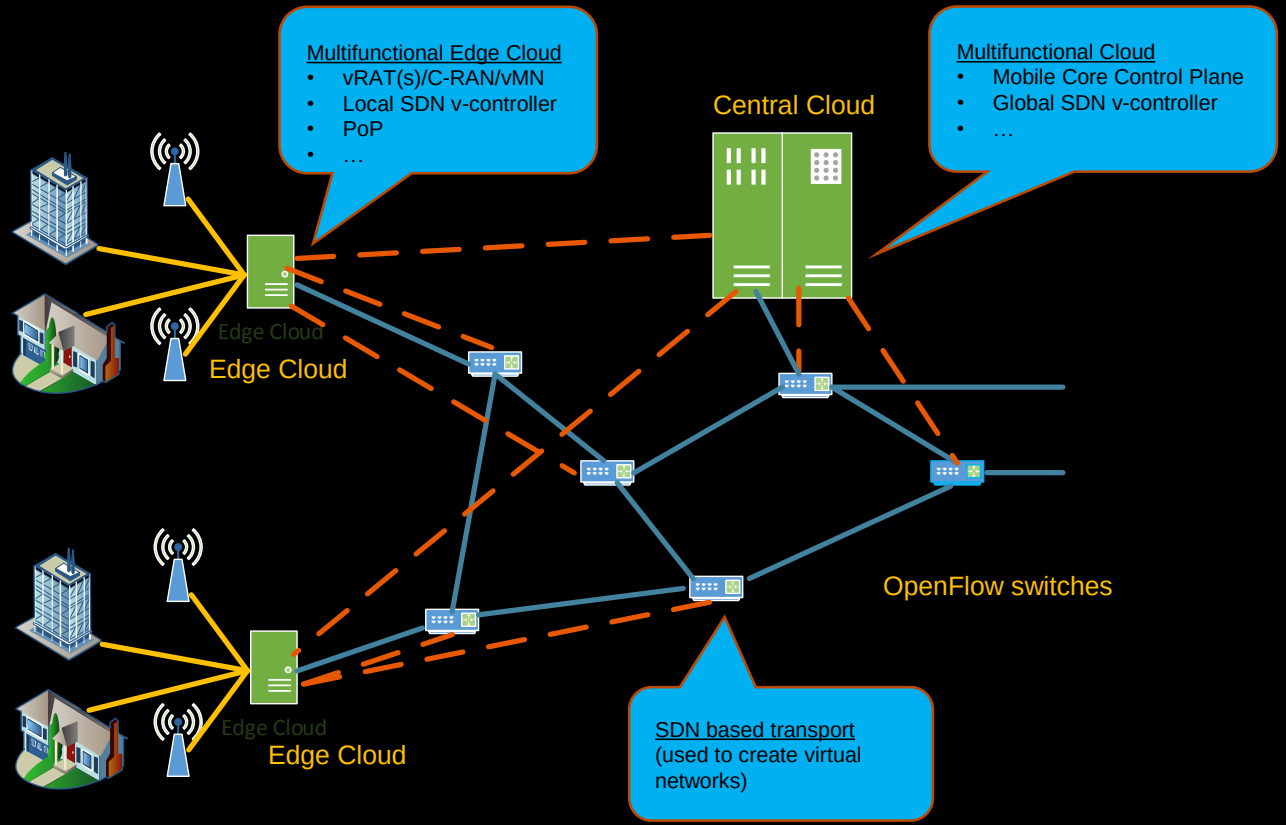
5G PPP

5GaaL: 5G as a LEGO

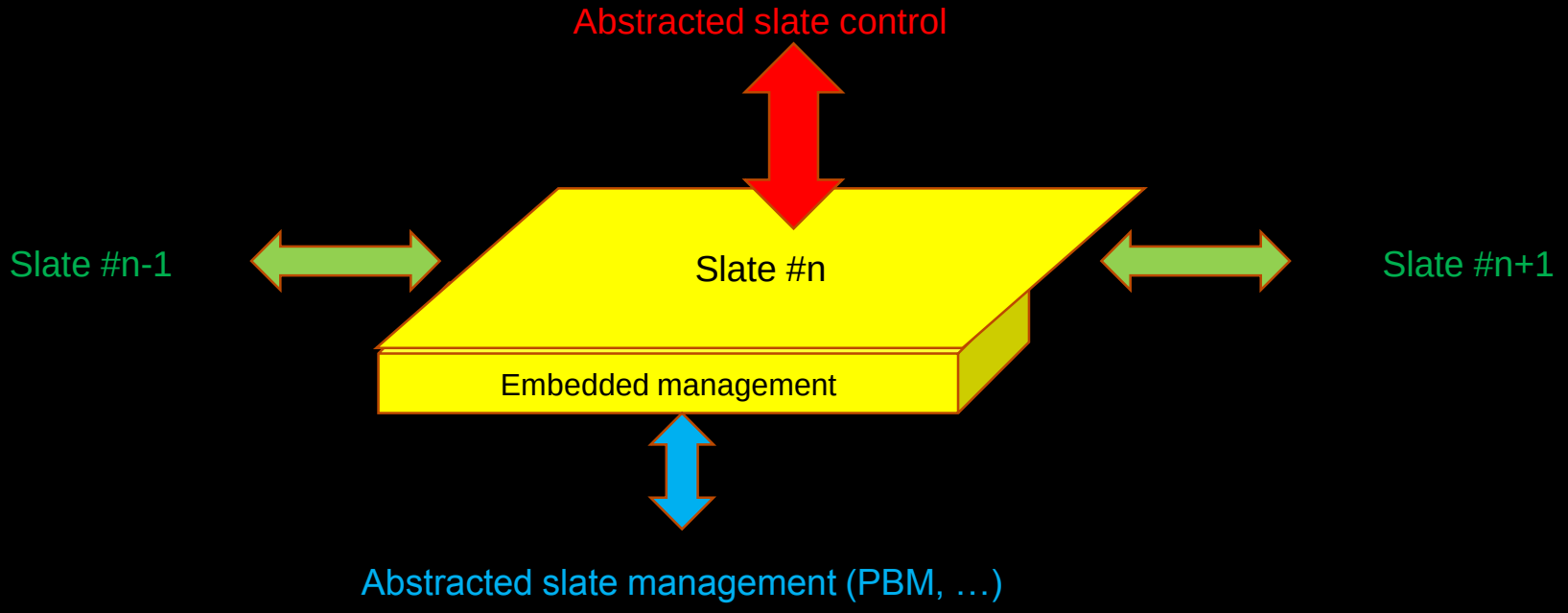
5GaaL: Design considerations

- RAN has complex intrinsic functions, but it offers **connectivity and mobility** (or mobility support). Having basic connectivity it is easy to add additional functions (as a part of a slice)
- We may use Edge Clouds for RAN implementation
  - to make C-RAN fronthaul shorter
  - the Edge Cloud can also be used for other purposes (for PoP, caching, applications, …) Convergent Edge Cloud enables fronthaul combined with FTTx. 5G CAPEX can be reduced (infrastructure is shared)! A new business model is enabled by such approach
  - Virtual Function migration mechanism can be used to provide Edge Cloud load balancing
- Instead of the omnipotent RAT multiple RATs can be implemented in Edge Clouds
- Slice provides an e2e connectivity. Let's introduce slate that provide per technological or administrative domain connectivity. Slice is a composition of multiple slates. Each slate has embedded self-managment
- Let's use network abstractions to build e2e connectivity (ONOS-like approach)
- SDN can be nicely adapted for 5G slice creation.

5Gaal: Infrastructure



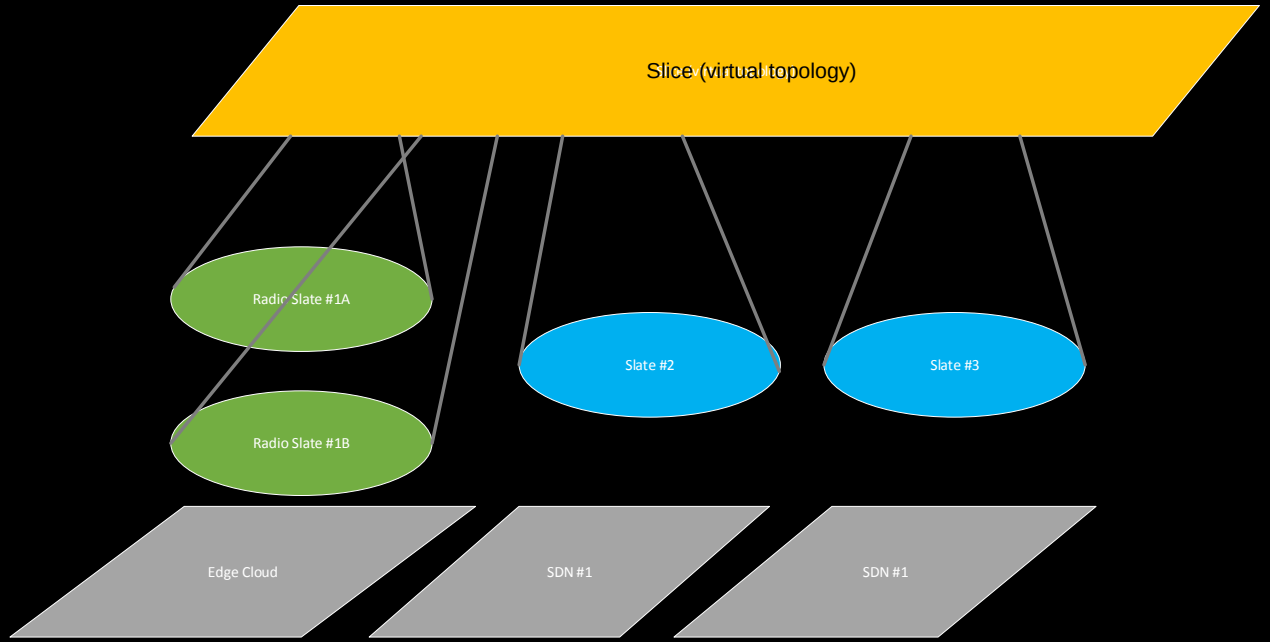
5GaaL: Slate abstraction



We may have Resource Slates and Network Slates

We may have wired and wireless slates

5GaaL: Slates, slices -example



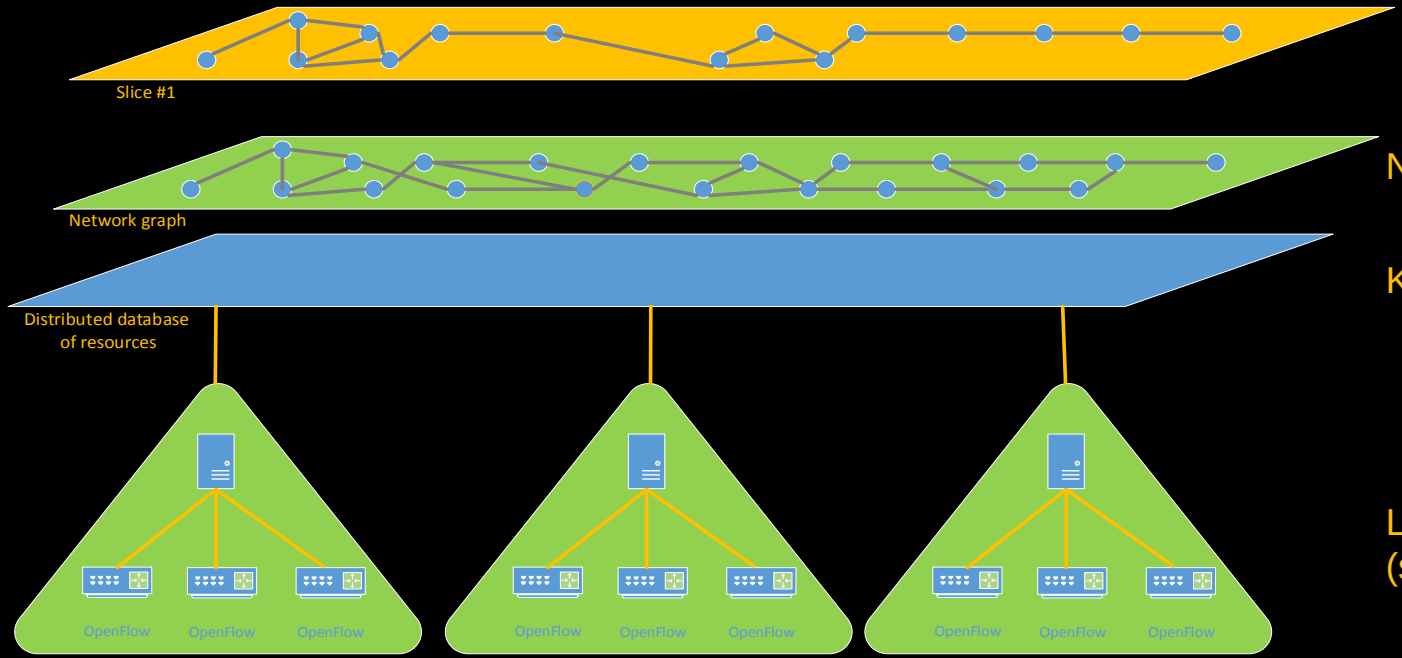
The network topology and usage is kept in a distributed database. Each slate exposes its topology in a simple form. Already solved for wired networks, to be solved yet for wireless ones.

Every slate has embedded management and offers simple connectivity services

Slates can be used in parallel (especially radio slates).

Radio slate abstraction to be developed yet

5GaaL: ONOS-like abstractions



Virtual network (slice)

Network graph

Key-values database

Local domains
(slates)

Radio-Slate abstractions

- We already have some abstractions related to RRM (Radio Access Bearer) or MM (paging, handover)
- We have 2 abstraction extremes: Link Abstraction and Virtual Mobile Network Abstraction (a complete network with HSS in each Edge Cloud, we may even think about inter-Slate roaming). We should live with multiple Virtual Mobile Network Abstractions – that way we can integrate existing, legacy mobile networks
- Between the abovementioned abstractions we may have Node Abstraction, RAN abstraction, and in general a hierarchy of abstractions (for the sake of programmability)
- There are some papers about RAN/RAT abstractions, but they are more focused on replicating RAN nodes functionality rather than providing ‚slate-like' functions
- In Radio- Slate abstraction we should include coverage maps, usage maps, interference maps etc.). Not easy.

Concluding remarks

- We should rethink the 5G architecture and make it modular as much as possible
- We shouldn’t replicate hardware in software (no more HDN menthality!)
- There are good reasons to compose slices out of slates (gradual deployment)
- Multiple RATs can be nicely combined with the slate based approach
- Using of connectivity/mobility abstractions for 5G functional blocks is of premium importance. A lot of work on RAN/Node/Mobile Network abstractions still to be done. Such abstractions makes orchestration relatively simple
- Multifunctional (shared) Edge Clouds can play important role as a part of 5G infrastructure (SDN too)
- Let’s separate tools/platforms from ‚core 5G functions’

Grazie