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Access Network

Mobile Evolution and Impact on Optical Access Network

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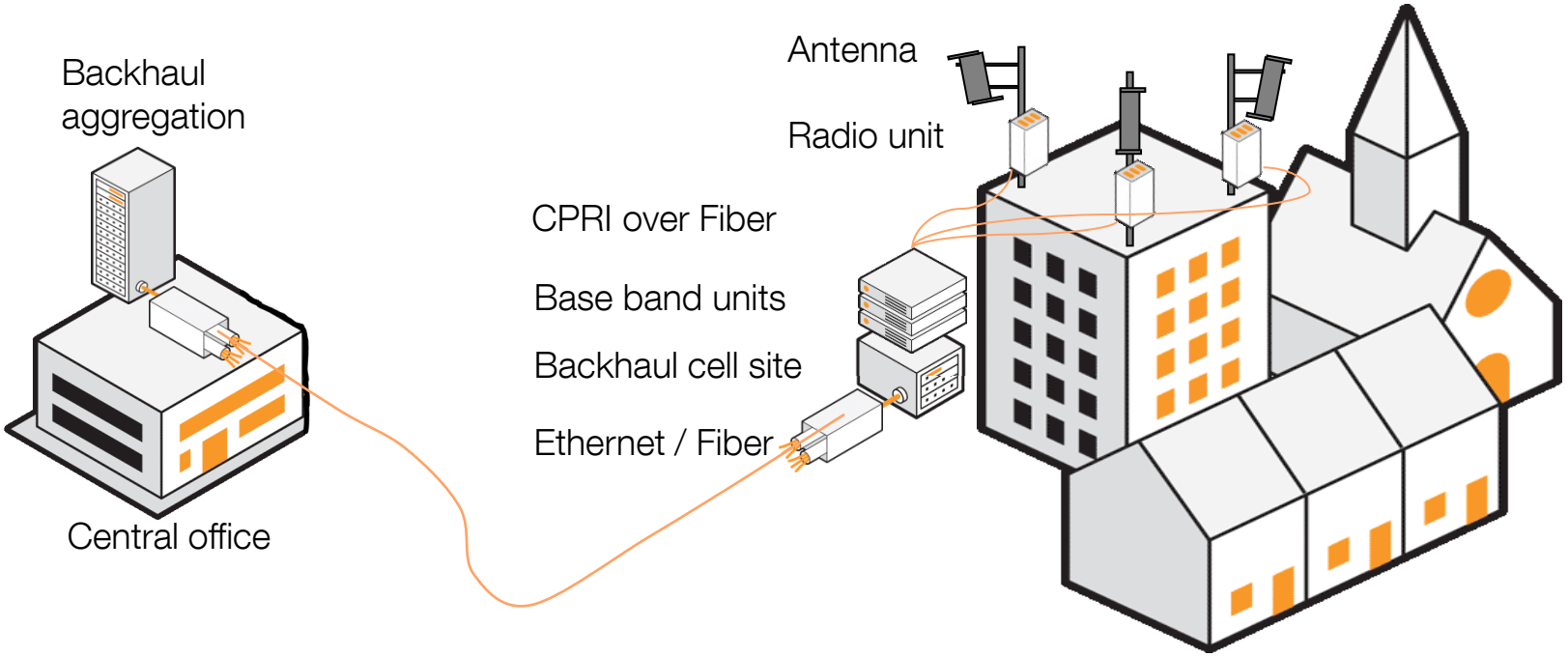
The Radio Access Network architecture : state of art

- The current mobile architecture with distributed RAN equipment.



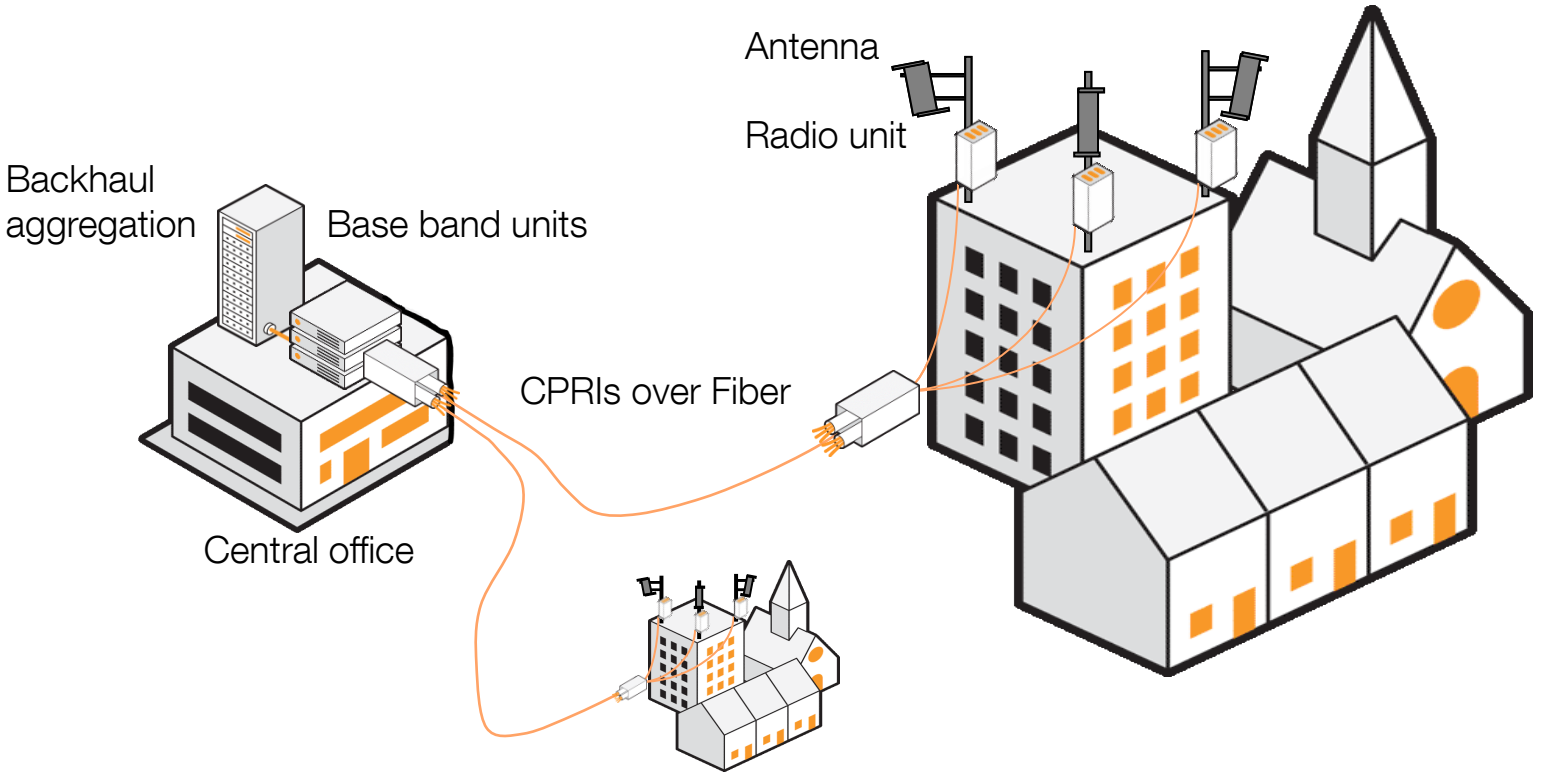
Which optical access technology to chose?

- The backhaul cell site is an aggregator of BBUs for data traffic based on Ethernet interface with synchronization (IEEE 1588).

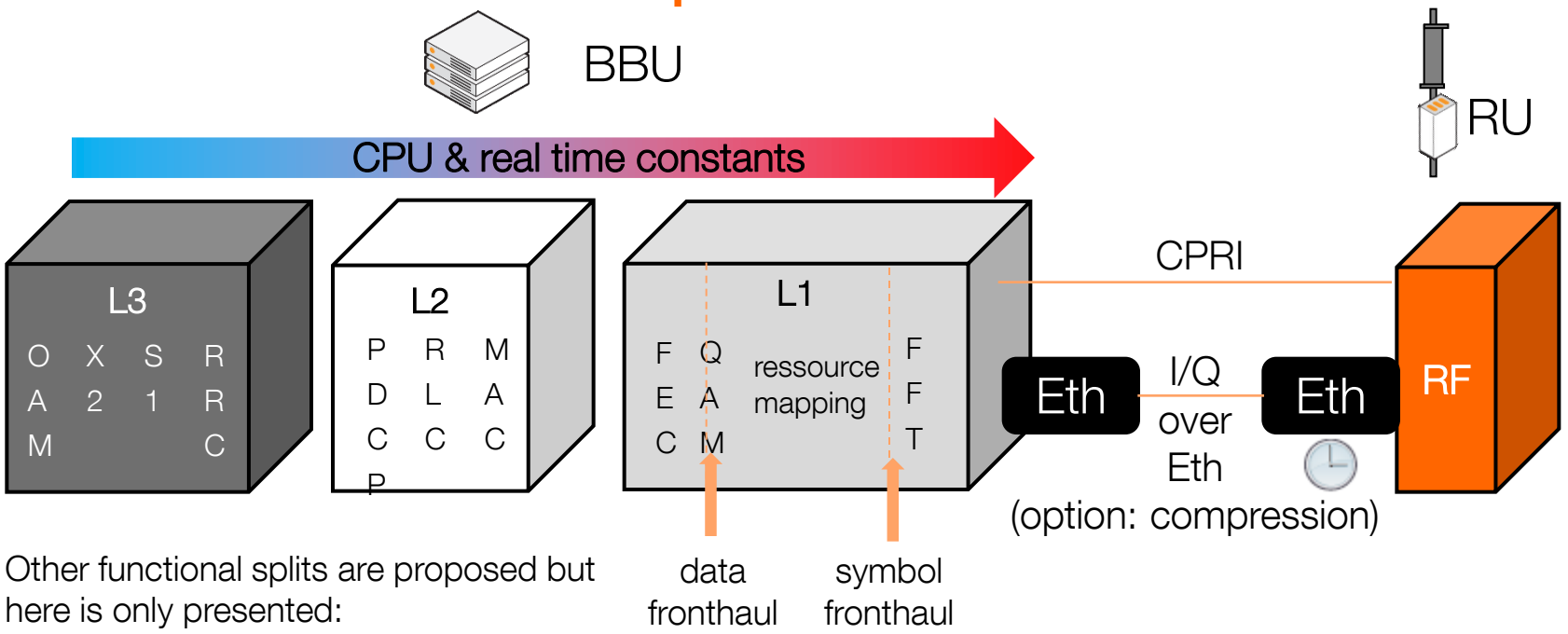
	Regular RAN (2G/ 3G/4G)
Link from cell sites to centralised site	Ethernet backhaul Fast/GigaEth.
Optical access technology	- shared fiber : G-PON, XG-PON1, XGS-PON, TWDM, PtP WDM… - PtP fiber

The Radio Access Network architecture : state of art « Cloud RAN »

- The current mobile architecture with centralized RAN equipment:
  - Phase1 : BBU centralisation (BBU-RU link based on CPRI)
  - Phase 2 : BBU pooling (BBU-RU link could be specified in the futur)



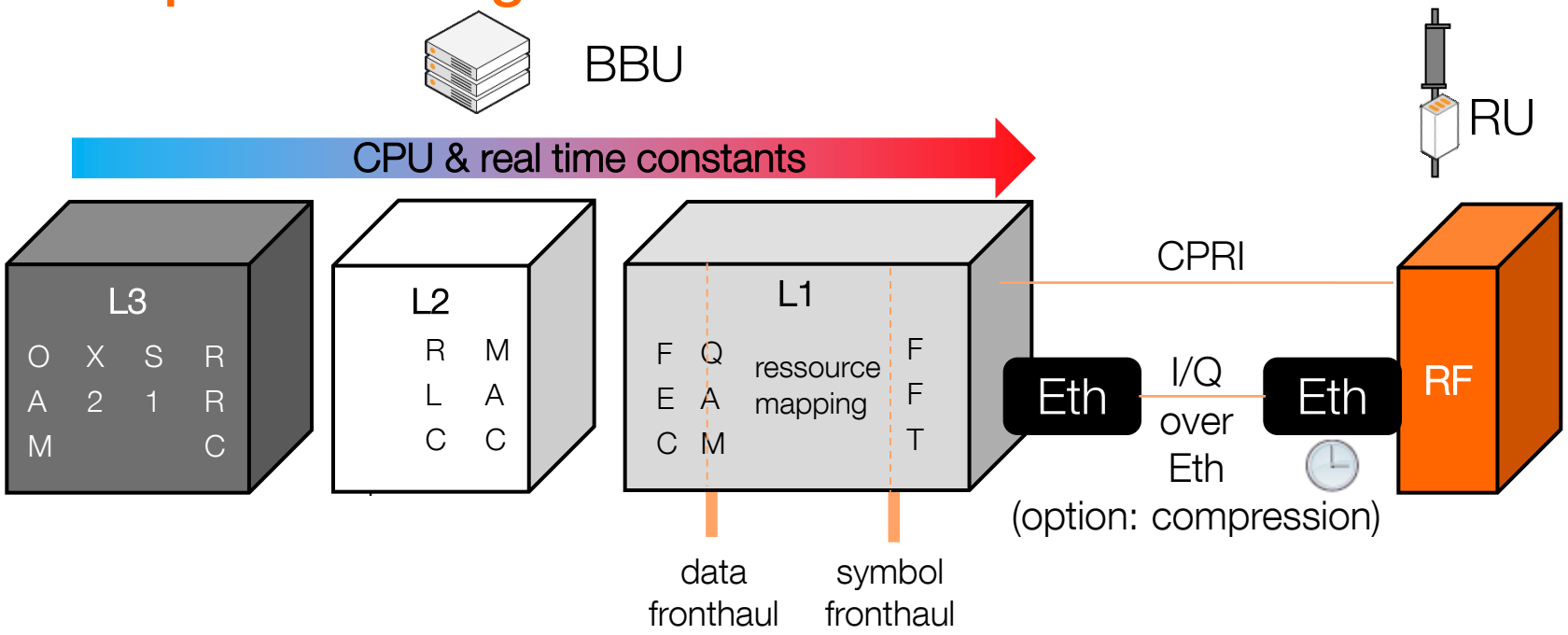
CPRI & new functional splits for C-RAN



Other functional splits are proposed but here is only presented:

	Radio cooperation	RU and interface complexity	Pooling gain
CPRI	High	Lowest	Large
IQ over Eth. (IEEE 1904.3)	High	Low	Large
Symbol fronthaul (Eth)	High	Low	Large
Data fronthaul (Eth)	Medium	Medium	Relatively small

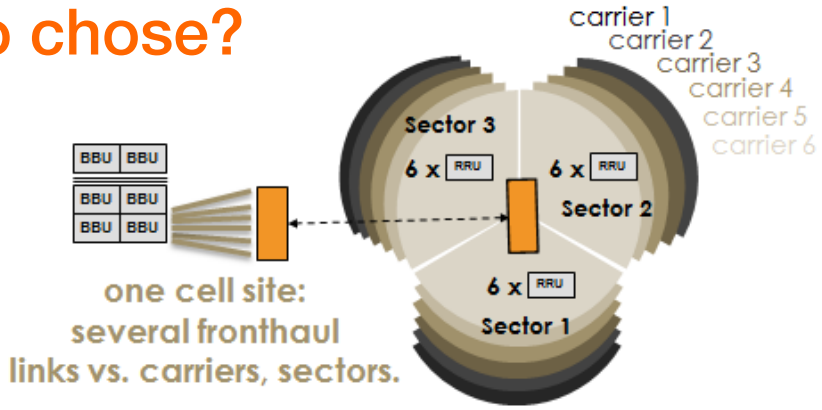
Transport challenge for C-RAN



	Data rate for 20MHz-2x2 (Max .rate)	Synchronisation	Latency
CPRI	2,5Gb/s (12Gb/s)	Native	<500µs
IQ over Eth. (IEEE 1904.3)	factor 3/4 with compression 1/4	needed (time sensitive network)	<500µs (including encapsulation time)
Symbol fronthaul (Eth)	factor ≈1/4 for Up and 1/20 for Down	needed (time sensitive network)	<1ms
Data fronthaul (Eth)	factor ≈1/20 for Up and 1/80 for Down	needed (time sensitive network)	<1ms

Which optical access technology to chose?

- Here, the issue is not only the transport, it is also to collect “n” radio unit interfaces over a single network infrastructure. Passive power or λ splitter, or active aggregator are localized at cell sites and BBU hotel for a n x n topology.



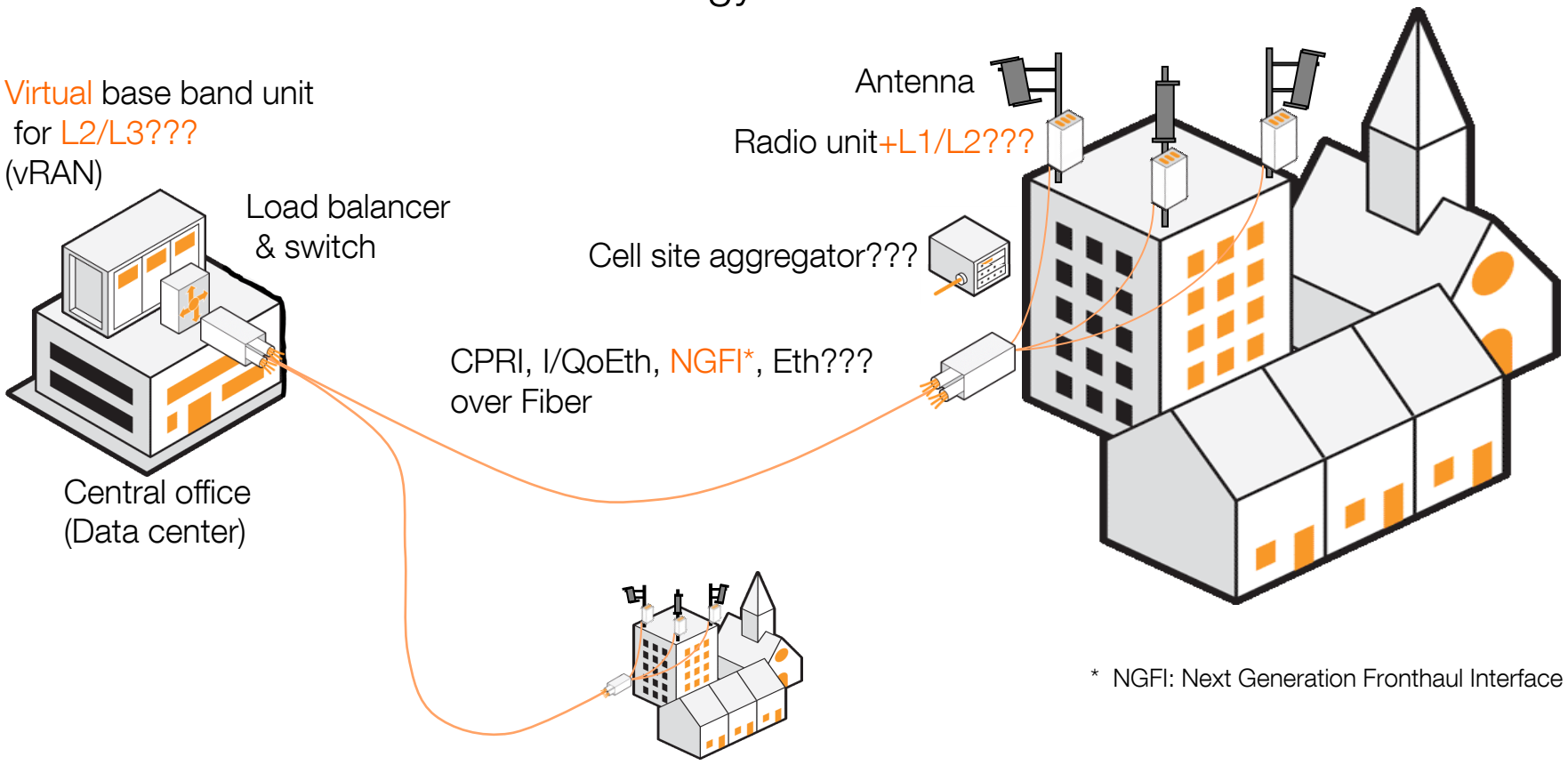
Cell site (5 carriers / 3 sectors)

	Cloud RAN			
Link from cell site to centralised site	n x CPRI	n x IQ over Eth. (1904.3)	n x symbol fronthaul aggregated (Eth)	n x Data fronthaul aggregated (Eth)
Optical access technology	- dark fibers - passive WDM - WDM transponder - PtP WDM PON (G.989)	- dark fibers - passive WDM - 10G (not enough?), 100G switch/router based on TSN* (IEEE 802.1) -TWDM & PtP WDM PON with time sensitive DBA	- dark fibers - passive WDM -10G switch/router (time sensitive network) - XG-PON1, XGS-PON, TWDM with maybe updated time sensitive spec.	

*TSN: Time Sensitive Network

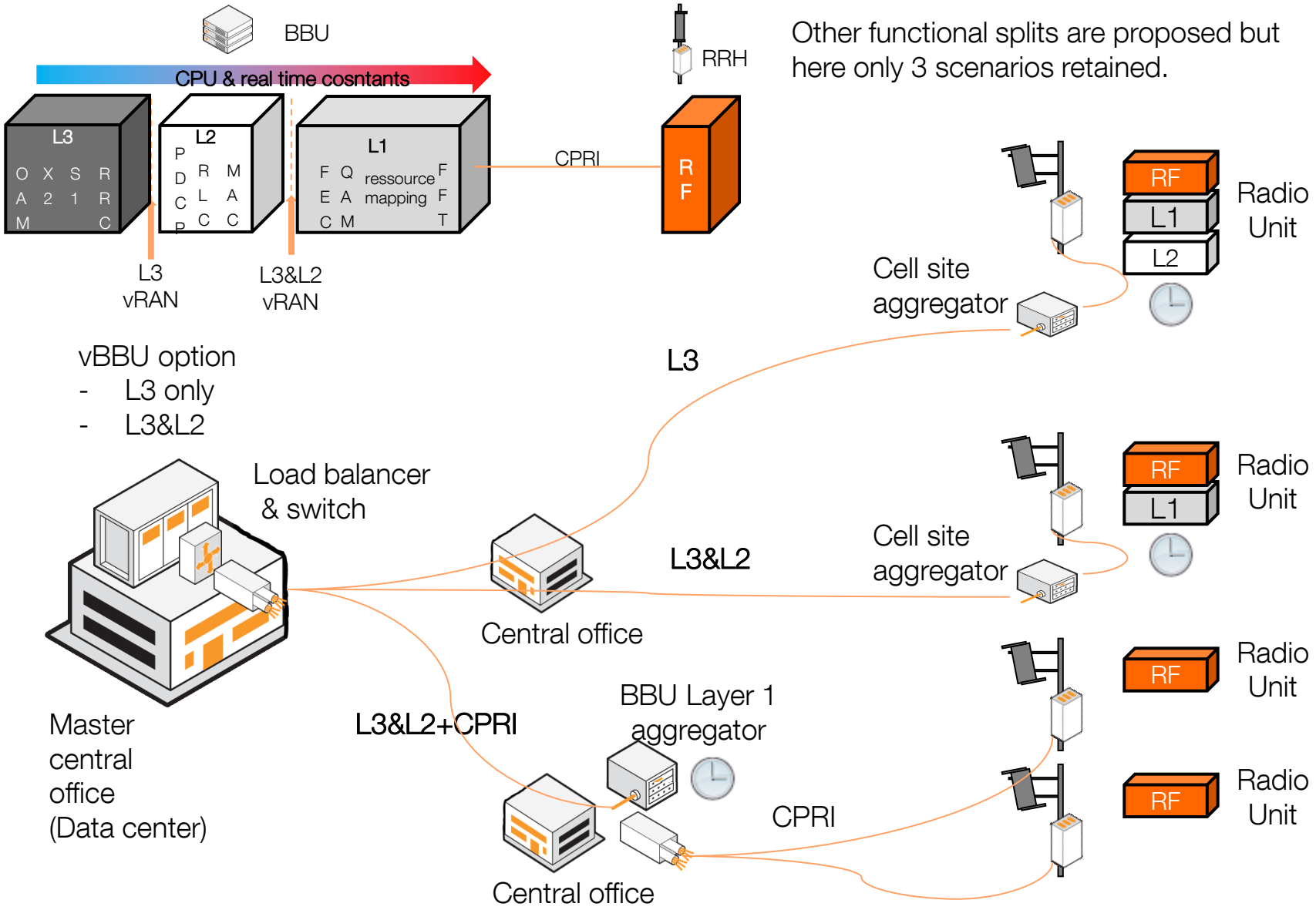
The Radio Access Network architecture : the coming « 5G »

- The target step of RAN architecture is the virtual RAN where a reconfigurable hardware is used. This architecture facilitates the dynamic adaptation of processing resources to the traffic request of available Radio Access Technology.

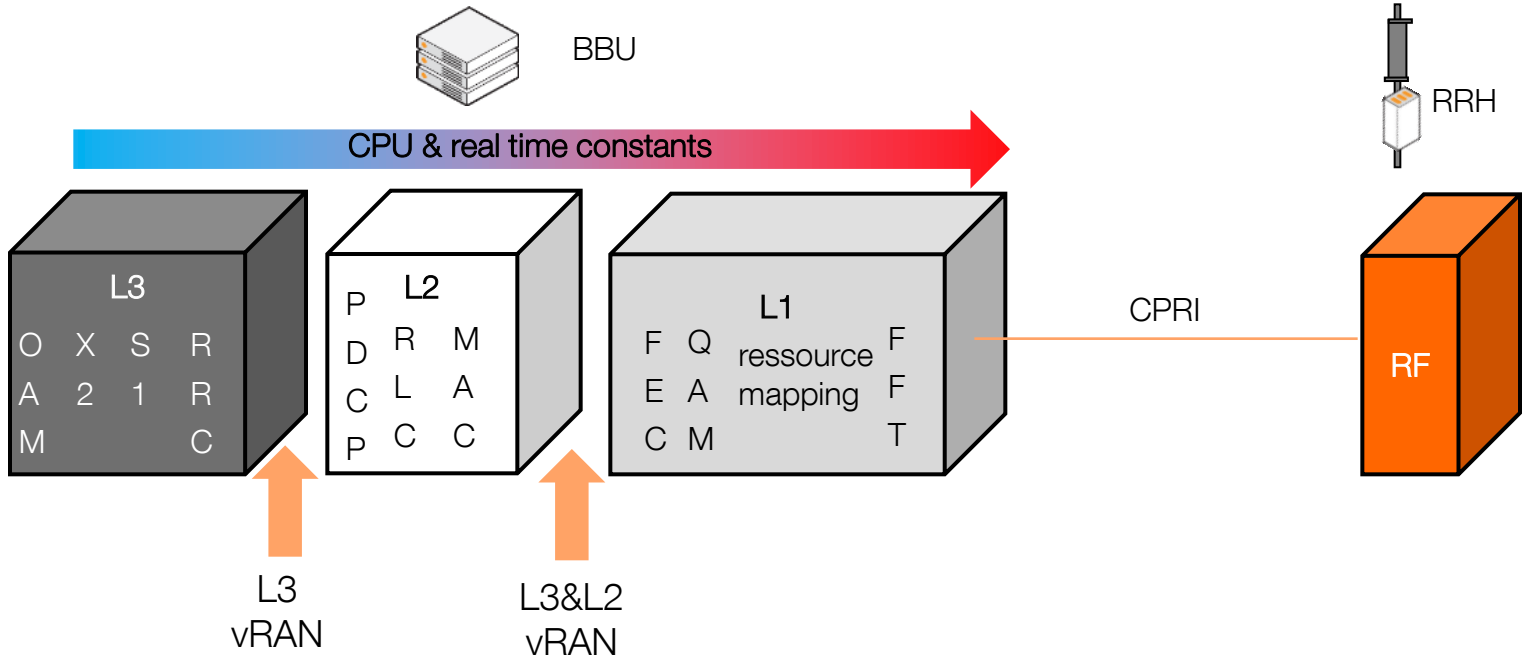


* NGFI: Next Generation Fronthaul Interface

Architecture options for vRAN 1/3

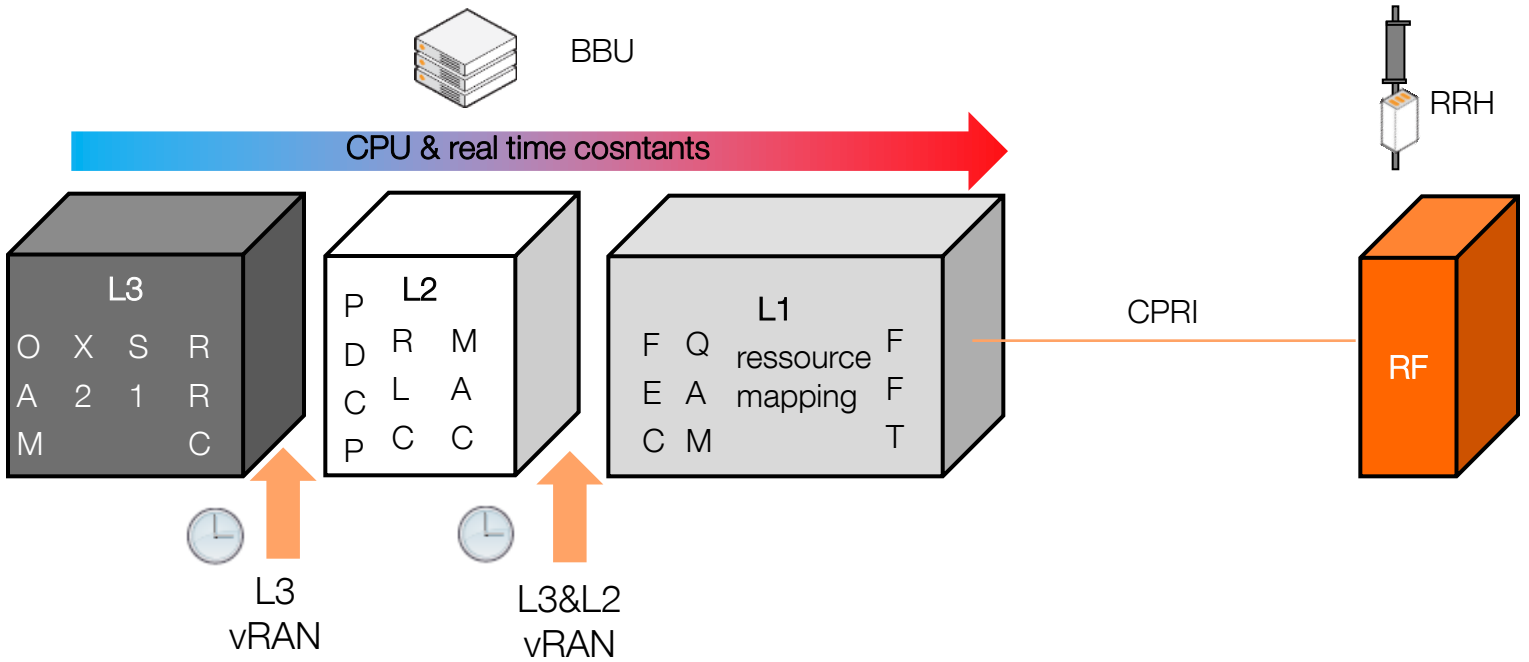


vRAN new functional splits



vRAN split	Radio cooperation	RU and interface complexity	Pooling gain
L3&L2+CPRI	High	Lowest for RU High for BBU L1 aggregator	Large
L3&L2	Poor	High	Relatively small
L3	Poor	High for RU Low for interface	Small

Transport challenge for vRAN



vRAN scenarios	Data rate for 20MHz-2x2	Synchronisation	Latency
L3&L2+CPRI	- n x 2,5Gb/s - n x 25Mb/s(up) & n x 50Mb/s(down)	Native for RUs TSN* for L1 aggregator	<500µs for CPRI <1ms for L3&L2
L3&L2	≈25Mb/s Up (100Mb/s) ≈50Mb/s Down (200Mb/s)	TSN*	<1ms
L3	≈25Mb/s Up (100Mb/s) ≈50Mb/s Down (200Mb/s)	TSN*	<100ms

*TSN: Time Sensitive Network

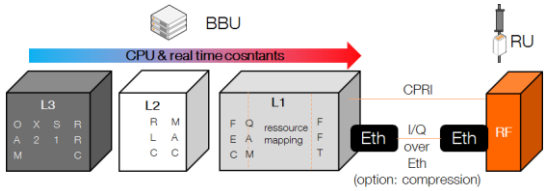
Which optical access technology to chose for vRAN?

	vRAN		
Link from cell site to centralized site	n x CPRI & L2&L3	L2&L3	L3
Optical access technology	- dark fibers - passive WDM - WDM transponder & see next column	Throughput for one cell site (5 carriers / 3 sectors) ≈ 0,5 to 3 Gb/s (maybe less if statistical multiplexing used at cell site aggregator) -1G or 10G switch/router TSN - XG-PON1, XGS-PON with updated TSN	

- Re-used existing backhaul equipment (switch, router,…) is not obvious but it is the main driver of these functional splits
- Several QoS (one per functional split?) need to be managed
- Operators needs a simple and single (compatible with all RAN vendors) fronthaul architecture

*TSN: Time Sensitive Network

Architecture options for vRAN



- Why is it so complex?
  - A part of the eNB cannot be virtualized and shall be located at the remote site: the radio unit, antenna…
  - The digital part has strong requirements in terms of CPU power and real time, especially on the L1 and L2
  - Thus the BBU has to be split in 2
    - A lower layer, managed by dedicated hardware, like DSP, FPGA or SoC
    - A higher layer, managed by GPP processor
  - Each standard organization and RAN vendor have its own views on the optimal split.
  - Where to split the BB? This is fully opened and driven by the tradeoff between:
    - Maximizing the management of the BBU on the virtualized infrastructure
    - Providing an efficient solution to operators, in terms of server size, power consumption, cost…
    - Supporting of some features that require multi-cells cooperation and/or beamforming using L1 processing
    - Bandwidth needed on the different fronthaul flavors

Conclusion

- The optical solution is a fundamental part of the vRAN trade-off (BBU location, cluster size, interface,…)
- Different network considerations will approach the trade-off in different ways:
  - The solution for macro cell likely to be different from the one for micro and small cell.
  - Co-existence on the same network of backhaul and fronthaul vs. greenfield fronthaul network
  - RAN migrations feasibility with smooth impact on optical network, ex: begin with n x CPRI and be compatible to any other interfaces
- No “single solution” is required for optical networks, scalable and pay-as-you-grow virtualized are the major optical fronthaul drivers
- Opportunity for optical access standardization (FSAN, ITU-T SG15 Q2)
  - definition of the Optical Distribution Network (infrastructure)
    - long term investments
  - definition of optical transport interface for supporting agnostic RAN
    - pay as you grow (follow RAN evolution, fast RAN renewal vs. FTTx…)

Thank you
Merci
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谢谢
감사합니다
ありがとうございました

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orange™