

Practical approach to converged FH/BH network architecture and functional partitioning

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NGFI
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Outline

- Architecture proposal for converged fronthaul and backhaul network for 4.5/5G RAN.
- Functional splits from a general purpose circuit point of view.
- Proposal NGFI **interfaces** and **functional splits**.

Objective

- Evolutionary path from 3/4G to 5G RAN.
- Identify the essential features from 4.5/5G RAN transport circuit & equipment realization point of view:
 - Flexibility vs Bandwidth/time-synchronization/complexity/cost.
- Propose an architecture and functional splits to 4.5/5G RAN that:
 - Allow E2E packet & Ethernet solutions.
 - Allow converged fronthaul and backhaul network deployments.
 - Scale up to 5G numbers keeping align with optics evolution.
 - Aim at transport level interoperability.

Disclaimer

- Most numbers (that are known & fixed) are for LTE/LTE-Advanced.
- 5G numbers are estimations at best based on the publicly available material from 3GPP.

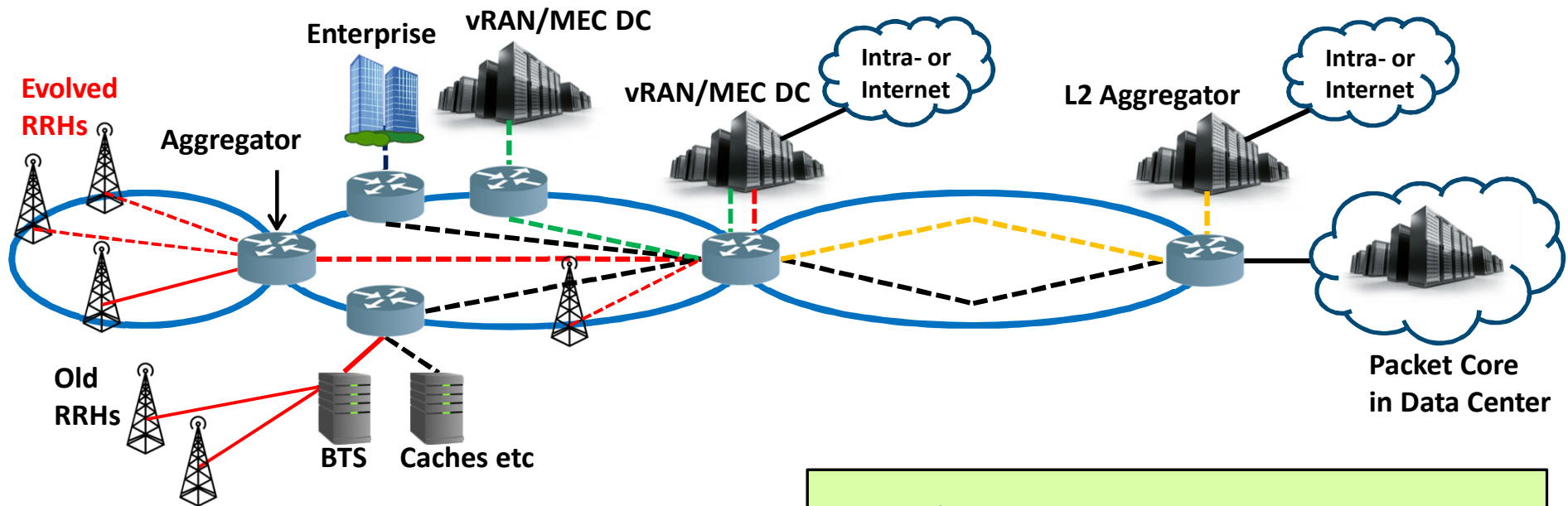
Architectural Motivations

- Relaxed backhaul bandwidth requirements, support for low latency applications and radio/proximity optimized applications.
- Converged fronthaul and backhaul with unified E2E networking infrastructure and OAM.
- Fully virtualized coordinated RAN.
- Reduced buffering in vRAN nodes and centralized higher layer radio resource/mobility management

Mistakes we must avoid

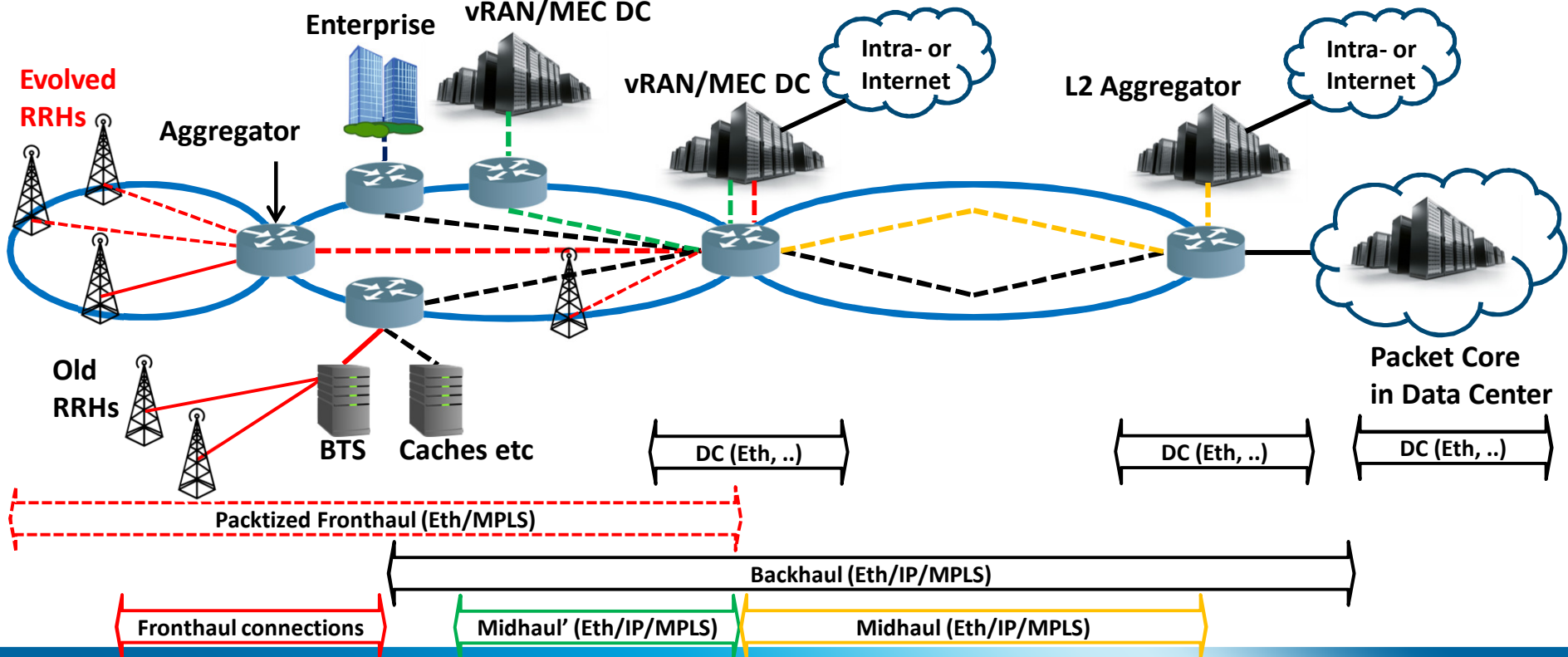
- One design for 4G and a new design for 5G:
 - Migration path is key.
 - Scalability is key.
- Overly complicated solutions (difficult path to interoperability).
- Solution requiring new transport architectures:
 - Leverage existing OAM, standard protocols, etc.
- Reinventing the wheel:
 - Reuse existing time-synchronization solutions.
 - Reuse existing time-sensitive networking solutions.

High level architecture – proposal

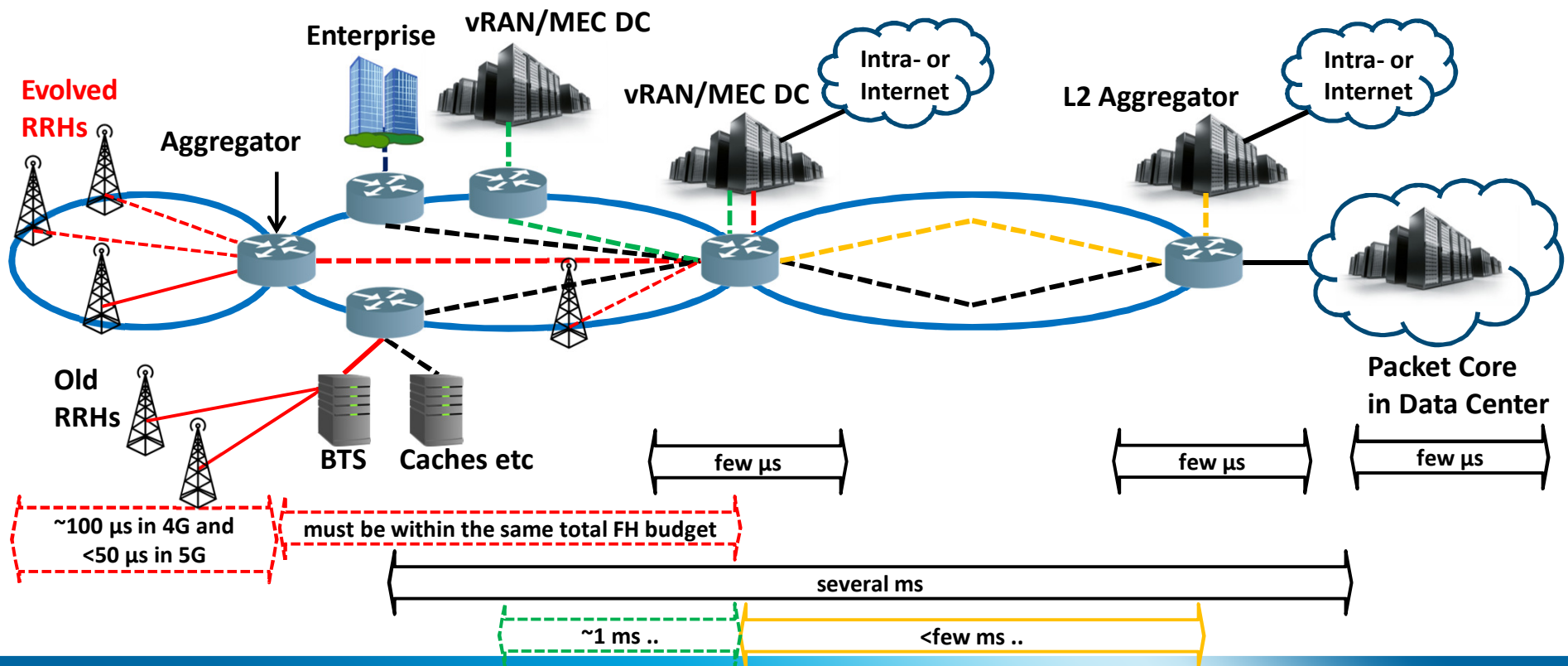


Legend:	
-----	IP/Eth/MPLS Backhaul
—————	Fronthaul (p2p connections)
- - - - -	Packet-based fronthaul
- - - - -	vRAN-vRAN X2-like midhaul
- - - - -	3C-like split midhaul

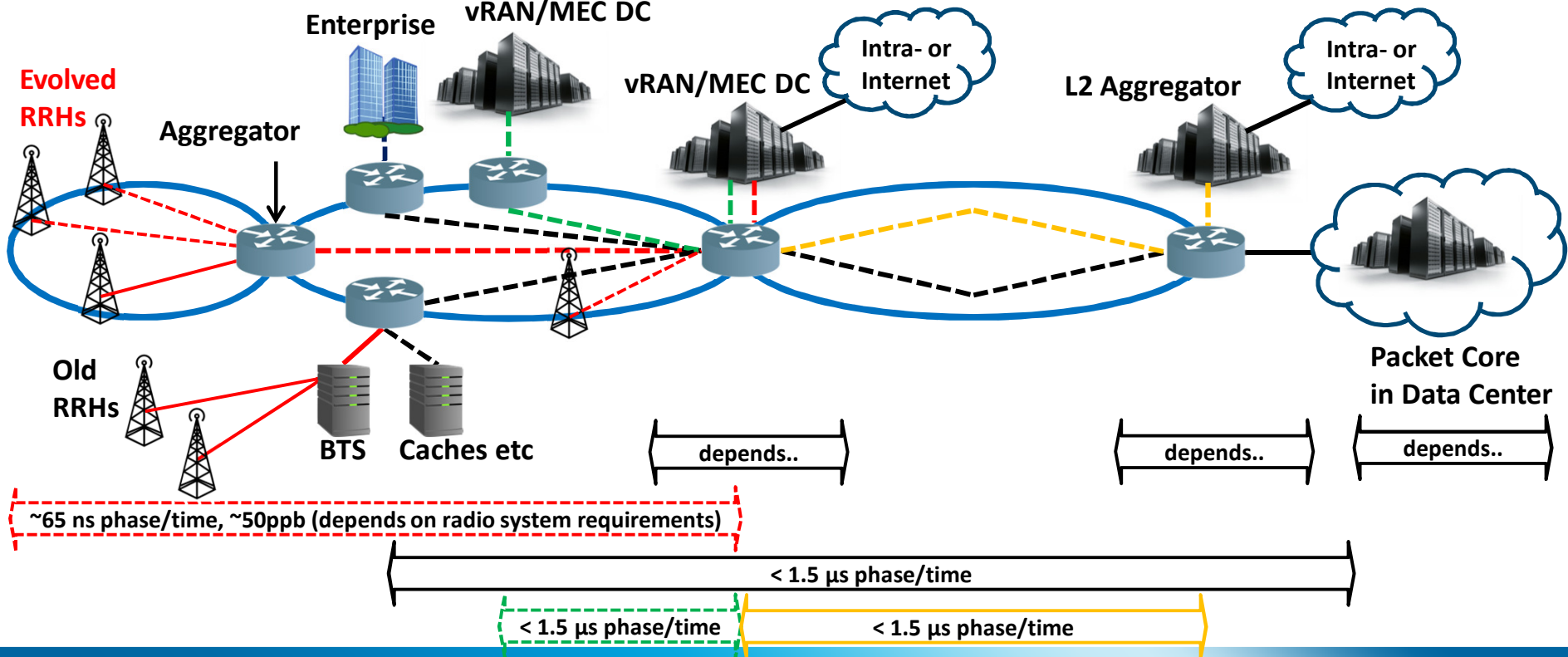
Transport view



Latency requirements



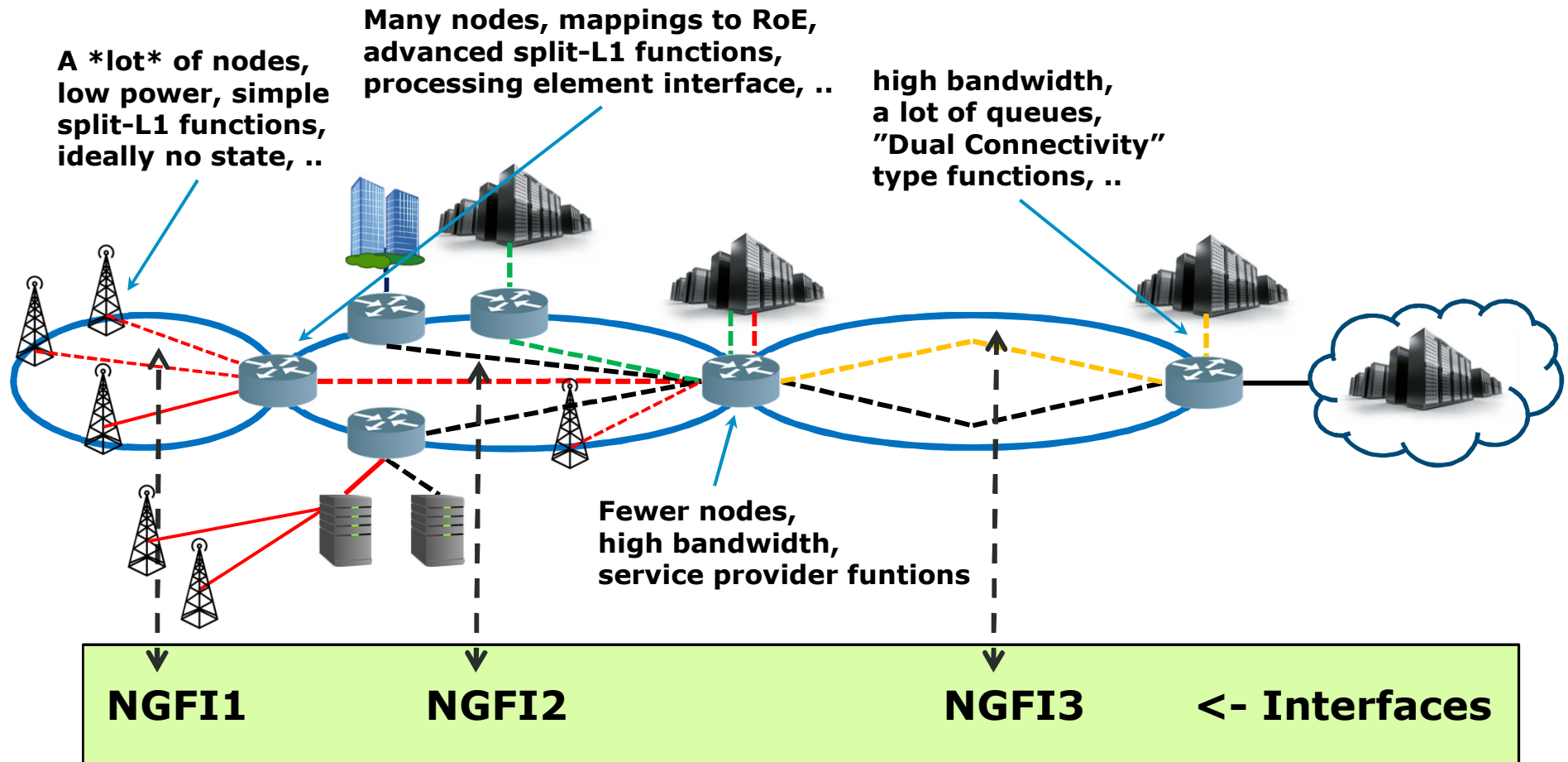
Time-synchronization requirements



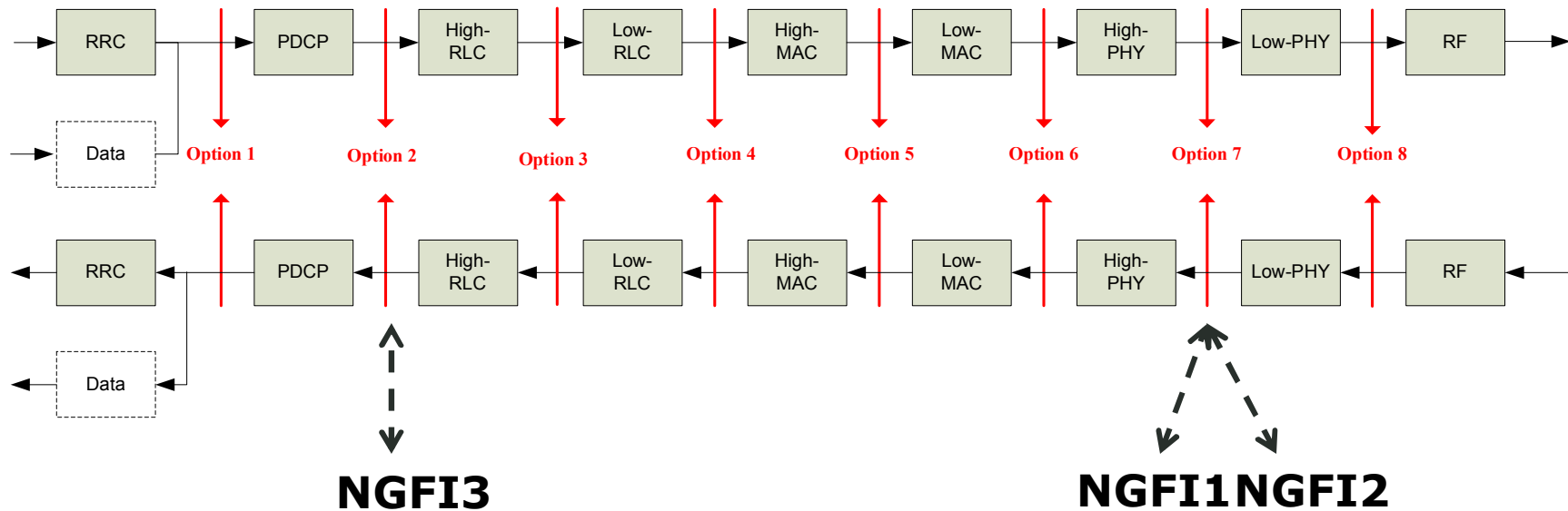
Summarizing..

- Multiple functional split points – not just how it splits in the radio stack but also how it fits into network architecture.
- Different functional splits affect latencies and synchronization requirements on specific parts of the transport network – they **do not change** the overall system level radio synchronization requirements
- Highly accurate Time-synchronization distribution becomes key.
- Traffic isolation (no traffic interferes other traffic) becomes key.

Networking nodes and Interfaces



3GPP TR38.801 functional split view

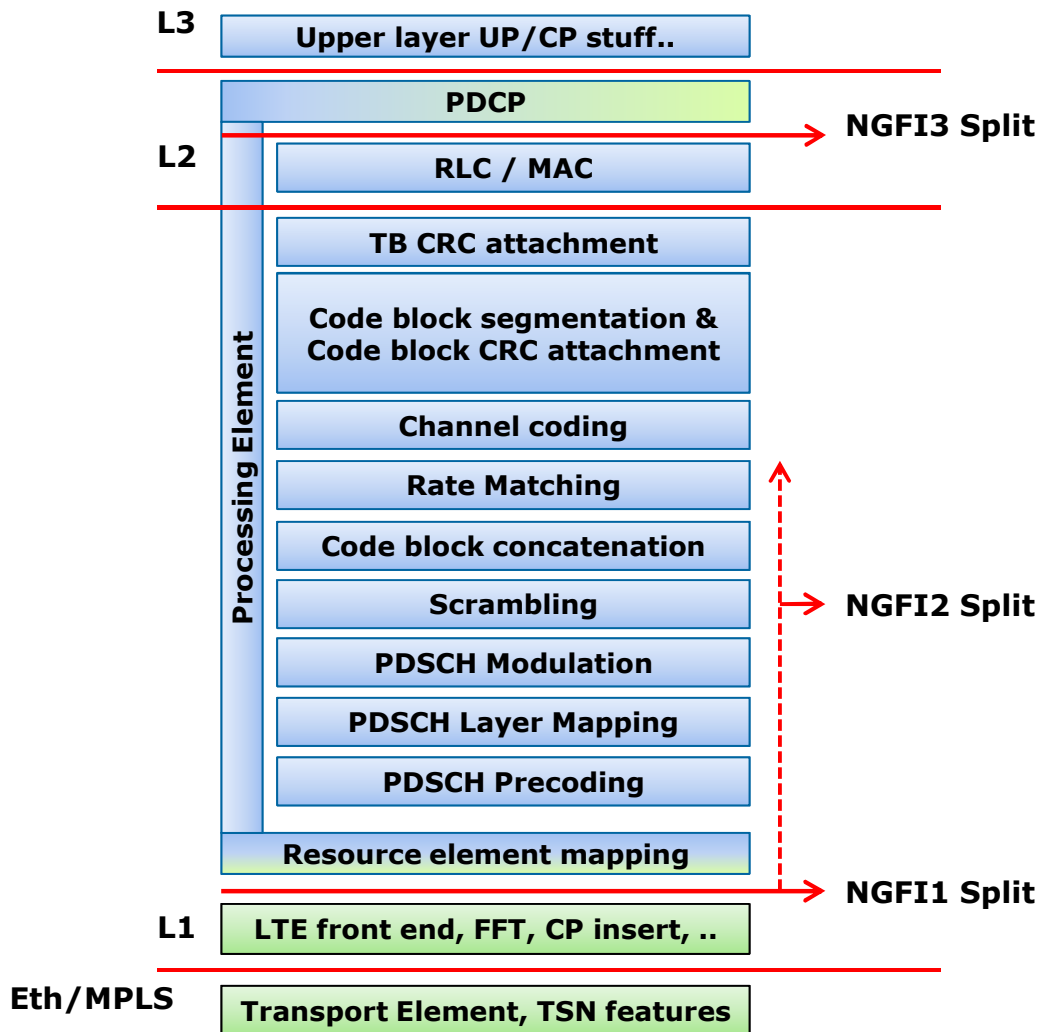


Each "interface" has different set of requirements to the networking.

Work in Progress Definitions

- Transport Element:
 - Low level packet forwarding functions and pipeline.
 - Simple and relatively static NGFI functions only.
 - Radio over Foo encap/decap including possible mappers.
 - TSN and time-synchronization features.
 - Standard functions and fully interaoperable!
- Processing Element:
 - Programmable.. complex NGFI (L1 and L2) functions.
 - No guaranteed interoperability except for transport & packetization of data.
 - Includes everything Transport Element.

LTE downlink "split" example following 3GPP TS36.212 and 36.211 layering



- NGFI3:
 - Dual Connectivity look-a-like – just IP transport.
- NGFI2:
 - Incremental to NGFI1; some parts likely outside the transport element.
 - Split point may float.
 - Converged FH and BH.
- NGFI1:
 - Keep it simple - "~same" functions in DL and UL.
 - Little radio expertise.
 - "No software"..

Requirements based on interfaces

NGFI1

Split functions:

- (I)FFT and CP insert/remove.

Transport latency/jitter:

- Few tens of μs – based e.g., on the FFT block size.

Time-synchronization:

- **$\sim 1\text{ns}$** timestamping accuracy (radio still has 65ns TA & 50ppb freq. accuracy or strickter..)
- 1588 + SyncE.
- OC/TC support.

Transport functions:

- Ethernet, MPLS (PW).

NGFI2

Split functions:

- NGFI1 + **mappers**.
- ..possibly upper PHY, PRACH handling, etc.

Transport latency/jitter :

- Around NGFI1..

Time-synchronization:

- NGFI1 + BC support.

Transport functions:

- NGFI1 + some service provider features.
- **Strict isolation & protection** (FH vs BH vs MH).

NGFI3

Split functions:

- 3GPP 3C-like (Dual Connectivity)..

Latency and Time-synchronization:

- Existing ITU-T and MEF specified for BH and MH.
- NGFI2 support.

Transport functions:

- Typical service provider features.

Some nodes may have dual role e.g., speak both NGFI1 and NGFI2, etc

The unknowns

- NGFI work is supposed to eventually cover "5G" but..
- However, the details of the 5G radio are still unknown:
 - Max bandwidth (200MHz?, continuous or CA style?)
 - Radio framing? TTI length? ng-HARQ? FFT block size?
 - Radio system level latency and time-synchronization requirements set by 3GPP..
 - etc..
- Dimensioning & deployment scenarios.. some numbers available in 3GPP TR38.913 but how accurately they reflect real deployments?

Proposal

- Define requirements and functions for a small number of splits (2? 3?).
- Functional splits should aim for simplicity:
 - Identify the most common and important functions that are easy to design "5G ready".
- **Adopt** the three interfaces proposed in this contribution as a baseline:
 - NGFI1 – simple split functions, high volume standard networking solutions with little software involvement.
 - NGFI2 – more complex split functions, aggregation, converged front- and backhaul, software functions are likely needed.
 - NGFI3 – "L2 splits" with full service provider functions.