

Sync Architecture Evolution for 5G NR

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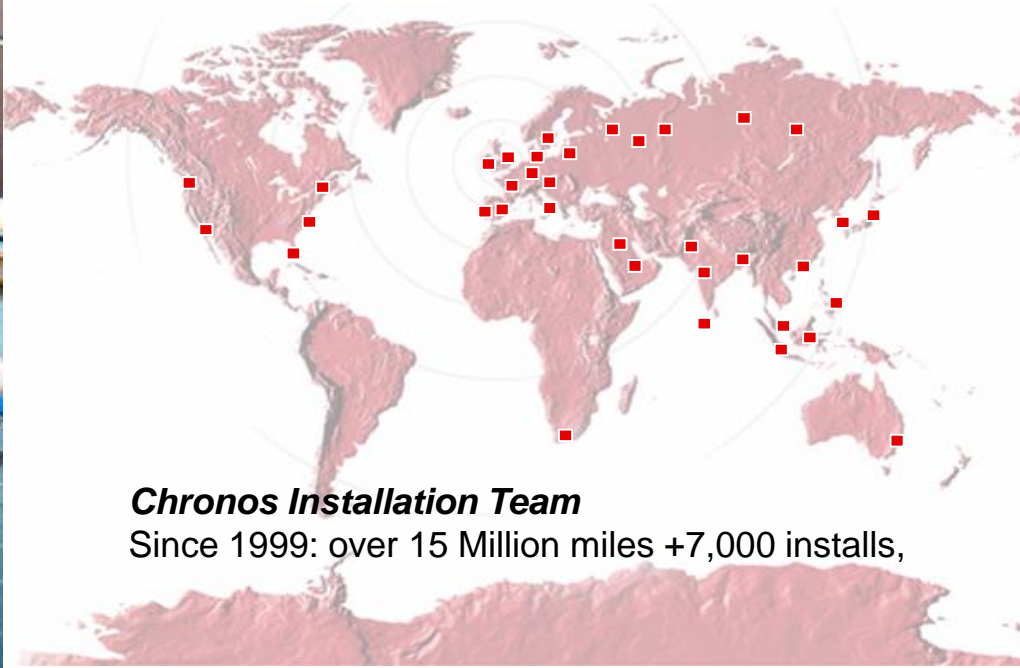
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Chronos Technology



- Global reach – installations + support
- ***Extensive experience of how GNSS timing systems behave in the real world***



Chronos Installation Team

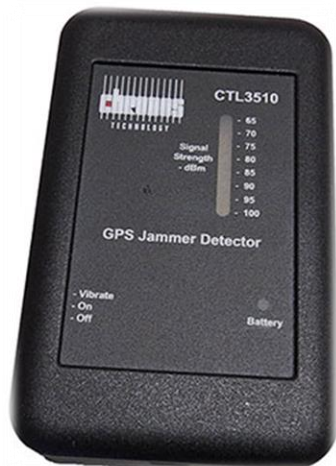
Since 1999: over 15 Million miles +7,000 installs,



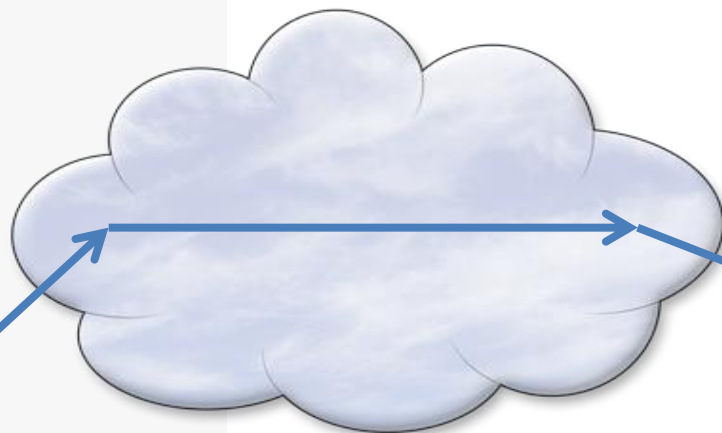
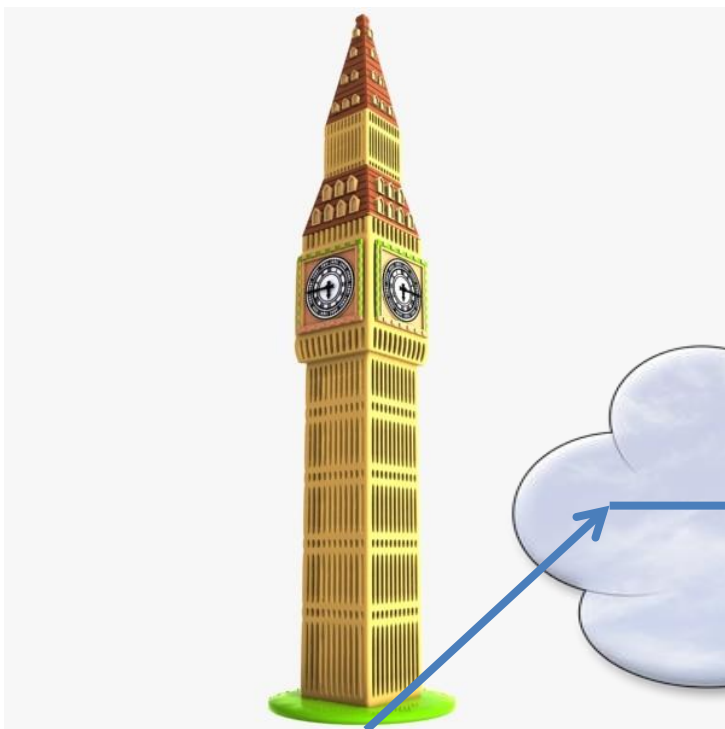
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- GNSS interference detection systems

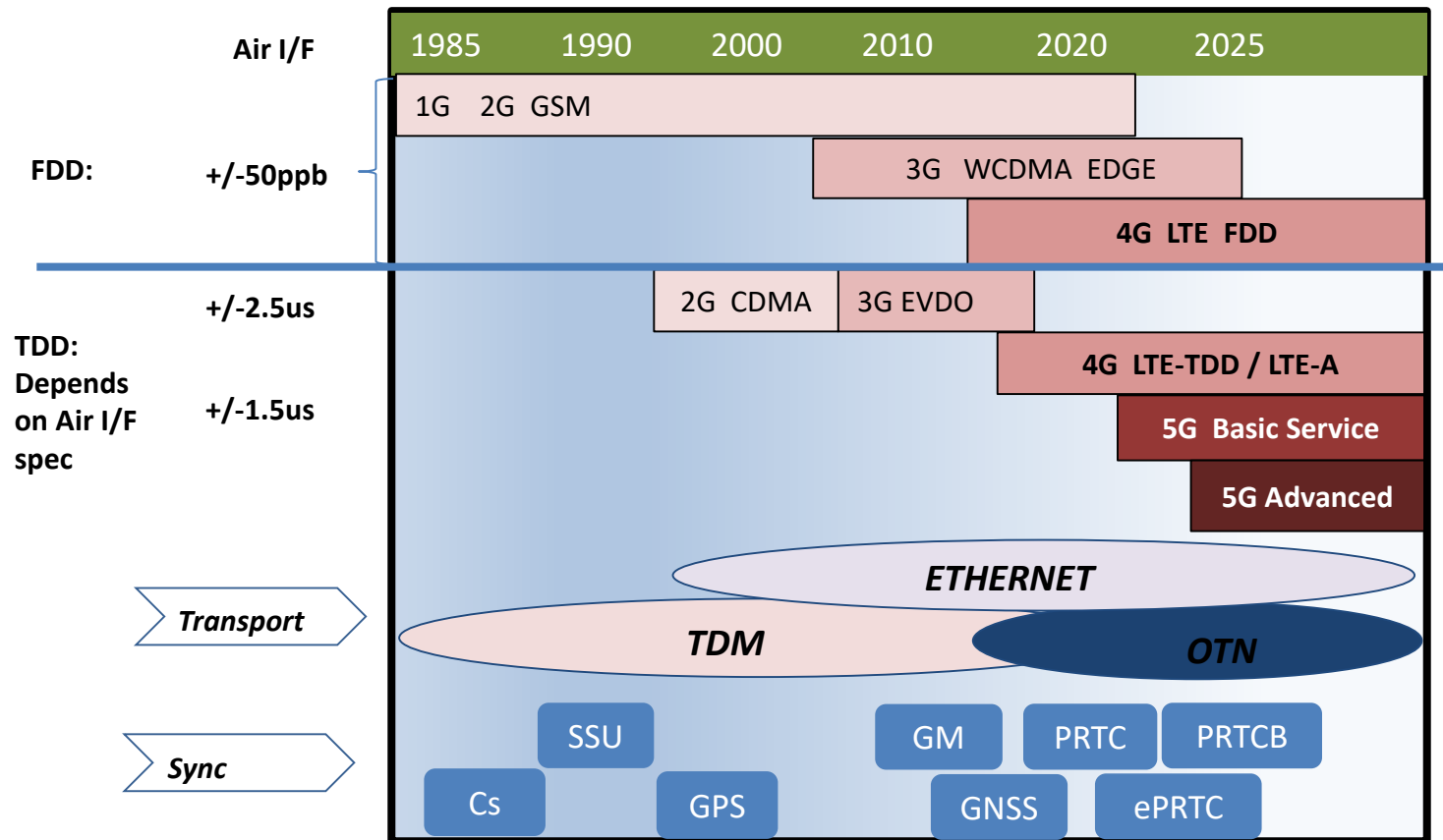


Back to basics



chronos
TECHNOLOGY

Evolution of Sync Requirements & Architectures



Faster Wireless connections **require & rely on** changes in network transport and in synchronization architectures in the Core and at the Mobile Edge

New specs, new clocks

- PRC to PRTC
 - No longer just stable & accurate frequency
 - Adds time/phase
- ePRC/ePRTC
 - Even better performance
 - PRTC-B
- GM to T-GM
 - ITU interpretation of IEEE1588-2008 (PTPv2) GM
- BC to T-BC
 - Class A/B/C/D
- GPS to GNSS
 - + GNSS firewalls

ITU-T Recommendations for Synchronization in Packet Networks



Basic Aspects

Network Requirements

Clocks

Methods

Profiles

G.8261: Timing and Synchronization Aspects in Packet Networks (Frequency)

G.8261.1: PDV Network Limits Applicable to Packet-Based Methods (Frequency)

G.8261.2: Reserved for future use

G.8262: Timing Characteristics of a Synchronous Ethernet Equipment Slave Clock (EEC)

G.8262.1: enhanced EEC

G.8263: Timing Characteristics of Packet-Based Equipment Clocks (PEC)

G.8266: Timing characteristics of packet master clock for frequency synchronization

G.8264: Distribution of Timing Information through Packet Networks

G.8265: Architecture and Requirements for Packet-Based Frequency Delivery

G.8265.1: Precision Time Protocol Telecom Profile for Frequency Synchronization

G.8265.2 PTP Telecom Profile for Frequency #2

Phase & Time

G.8271: Time and Phase Synchronization Aspects in Packet Networks

G.8271.1: Network Requirements for Time/Phase Full on Path Support

G.8271.2: Network Requirements for Time/Phase Partial On Path Support

G.8272: PRTC (Primary Reference Time Clock)

G.8272.1: enhanced PRTC

G.8273: Packet-Based Equipment Clocks for Time/Phase: Framework

G.8273.1: Grandmaster (T-GM)

G.8273.2: Boundary/Slave Clock (T-BC/T-TSC)

G.8273.3: Transparent Clock (T-TC)

G.8273.4: Assisted PTS Telecom Time Slave Clock

G.8274: Reserved for future use

G.8275: Architecture and Requirements for Packet-Based Time and Phase Delivery

G.8275.1: PTP Telecom Profile for Time/Phase Synchronization, Full OPS

G.8275.2: PTP Telecom Profile for Time/Phase Synchronization, Partial OPS

agreed

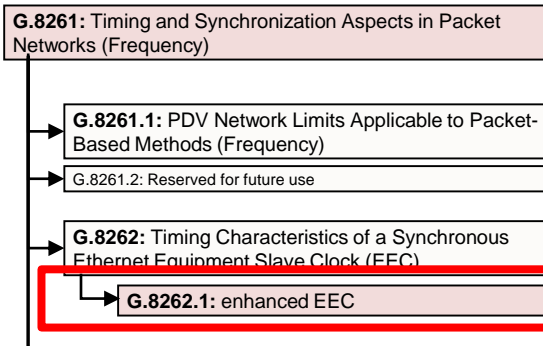
ongoing

options

ITU-T Recommendations for Synchronization in Packet Networks



Frequency



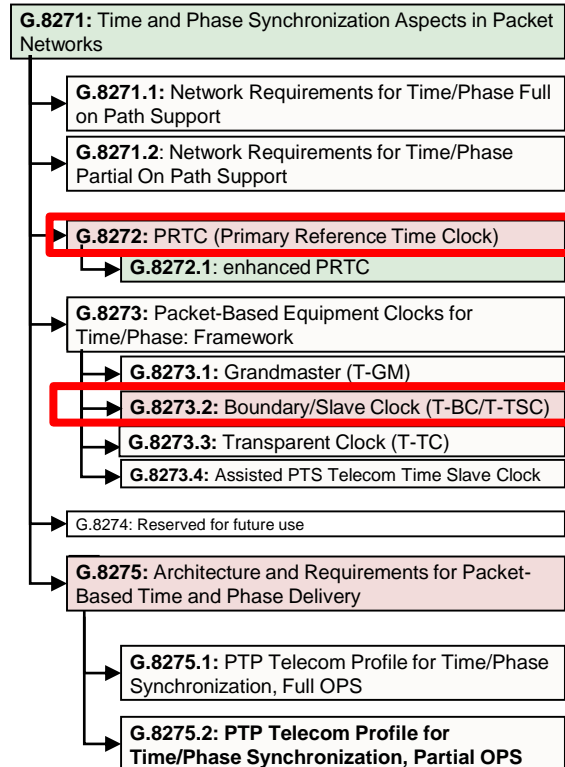
Now Consented

eEEC	better noise control
PRTC-B	+/-40nsec max Time Error
BC Class C	+/-10nsec max Time Error

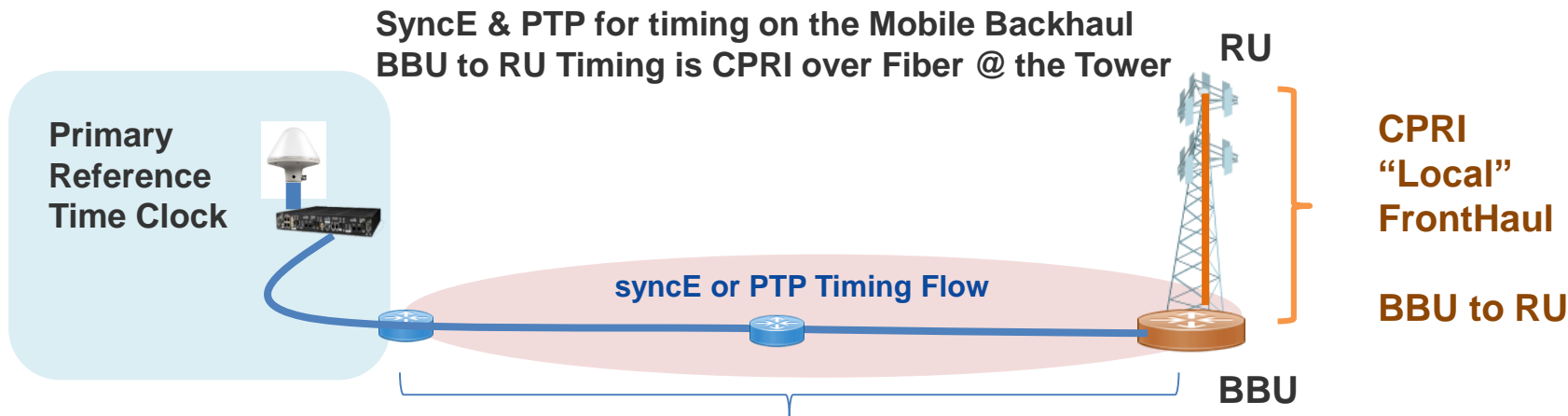
WIP

BC Class D	+/- 5nsec max Time Error
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Phase & Time



4G Time Error: Mobile Backhaul/Local Fronthaul

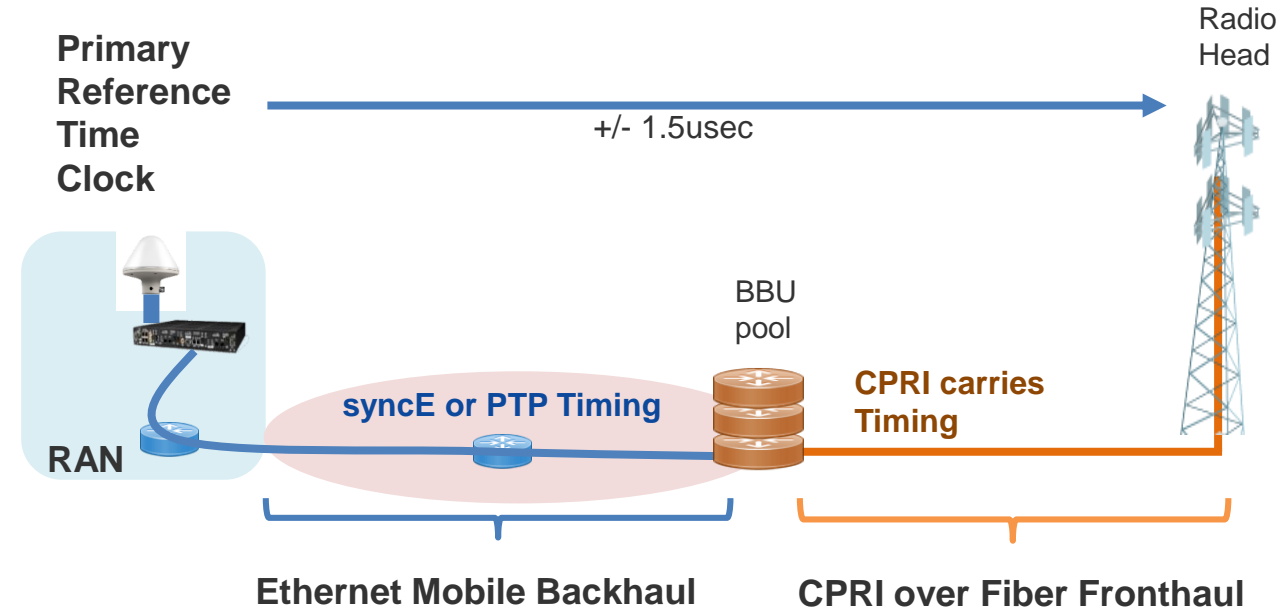


PRTC +/-100ns	Transport +/-1us	BBU to RU ±400ns
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End to End Time Error Budget = +/- 1.5usec

4G cRAN:

CPRI over Fiber Fronthaul/BBU Aggregation



Issues with CPRI

- Power hungry
- Proprietary
- Expensive
- Requires many BBU

Fronthaul TE budget still $\pm 400 \text{ nsec}$

CPRI cannot deliver 5G bandwidth to the UE

PRTC $\pm 100 \text{ ns}$	Transport $\pm 1 \mu\text{s}$	CPRI Fronthaul to RU $\pm 400 \text{ ns}$
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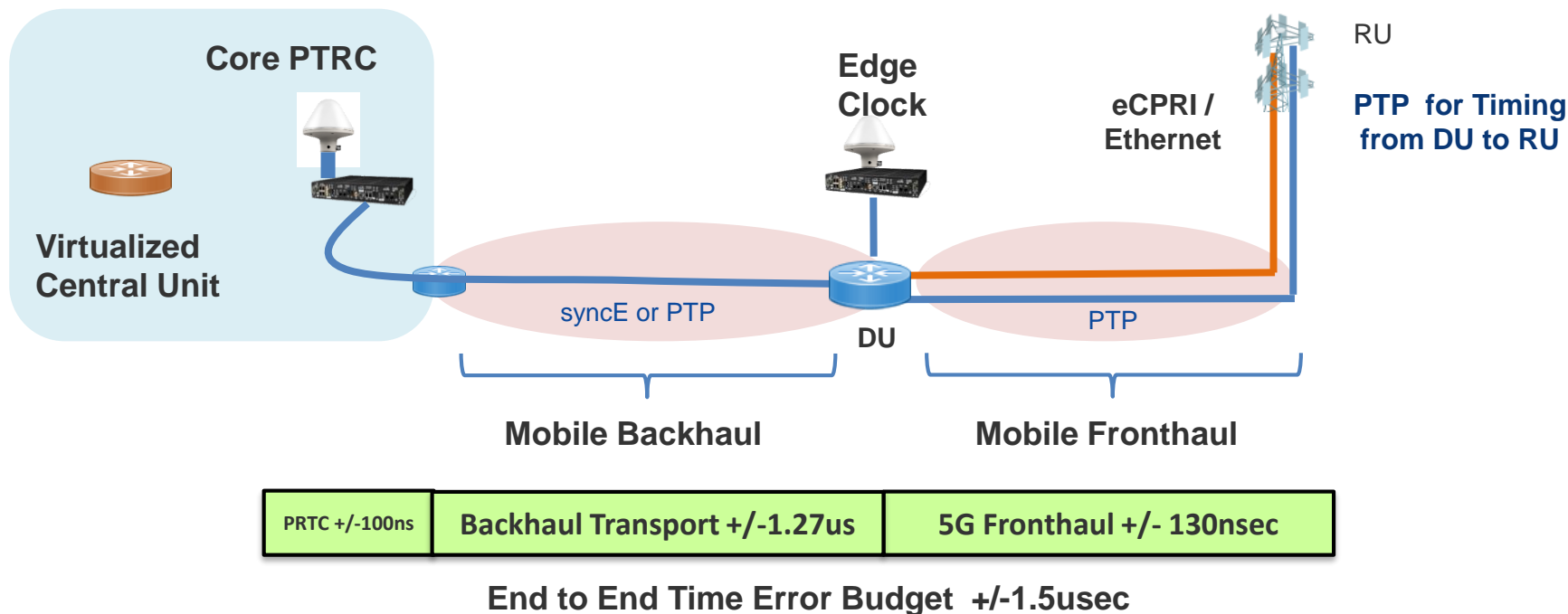
End to End Time Error Budget = $\pm 1.5 \mu\text{sec}$

5G Advanced Services: PTP Replaces CPRI for Timing



Centralized Unit (CU) and Distributed Unit (DU)

Fronthaul TE Budget reduced from +/-400 to +/- 130 nsec to enable Advanced Services

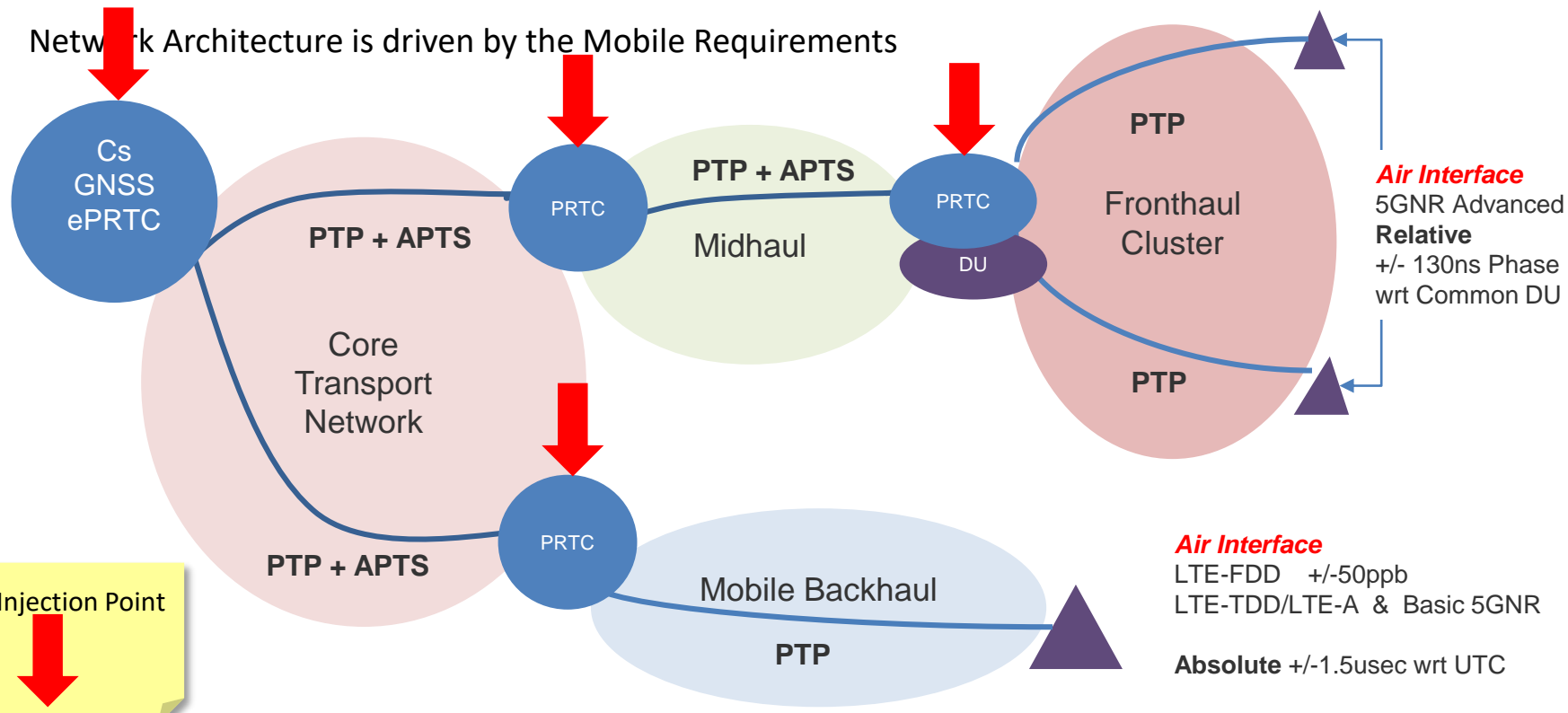


4G & 5G Synchronization Architecture:

High Precision Core Clocks for Holdover, Distributed PRTC for Phase at the Network Edge

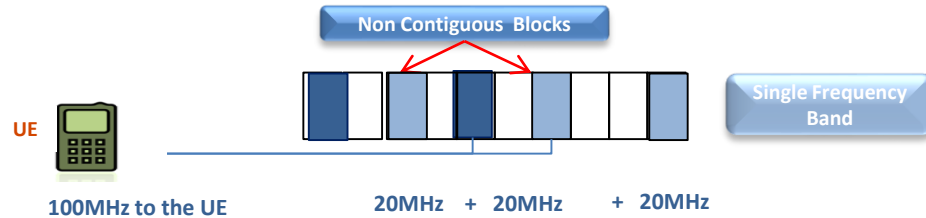


Network Architecture is driven by the Mobile Requirements

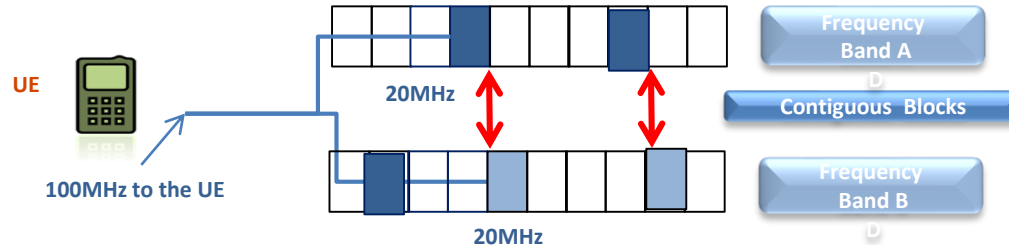


5G NR: Advanced Carrier Aggregation Services, wideband to the UE requires stringent TAE control to mitigate CoChan Interference

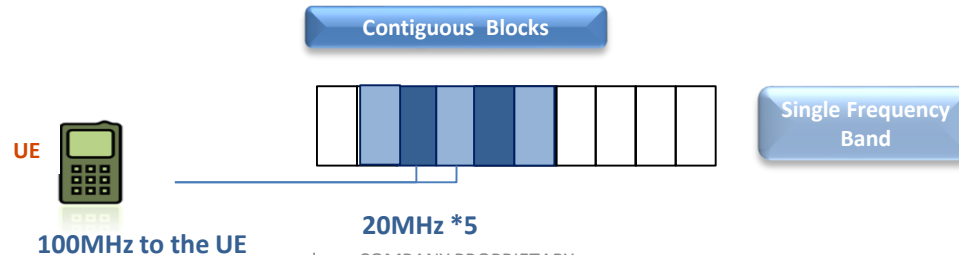
Intra-Band Non-Contiguous CA:
+/-260ns



Inter-Band Contiguous CA: +/-
260ns



Intra-Band Contiguous CA: +/-
130ns



Physical realisation

- Massive (Magic) MIMO
 - 64T64R – space division multiple access
- Complexity of Antenna design means electronics and (high) power consumption now right at the top of the mast
- Oscillators more exposed to extremes of temperature compared to typical cabinet housing

Summary



- Delivery of freq/phase/time is fundamental to 5GNR reliable & efficient operation
- Network architecture revolution presents challenges:
 - “Sync Injection points” have increased dramatically, new clock types means there’s no “one size fits all” solution
 - Many more clock types
 - GNSS/T-GM/PRTC/T-BC/edge clocks

A close-up, black and white photograph of several interlocking metal gears, creating a complex, mechanical pattern.

Thank you




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[Chronos PhaseReady Event: The 5G Field of Dreams](#)

3 OCTOBER 2019, KINGS PLACE, LONDON

As all UK networks roll out their initial 5G coverage, what does that mean for customers? What do...

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