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Precise time. Synchronized.

Synchronizing the Cloud RAN

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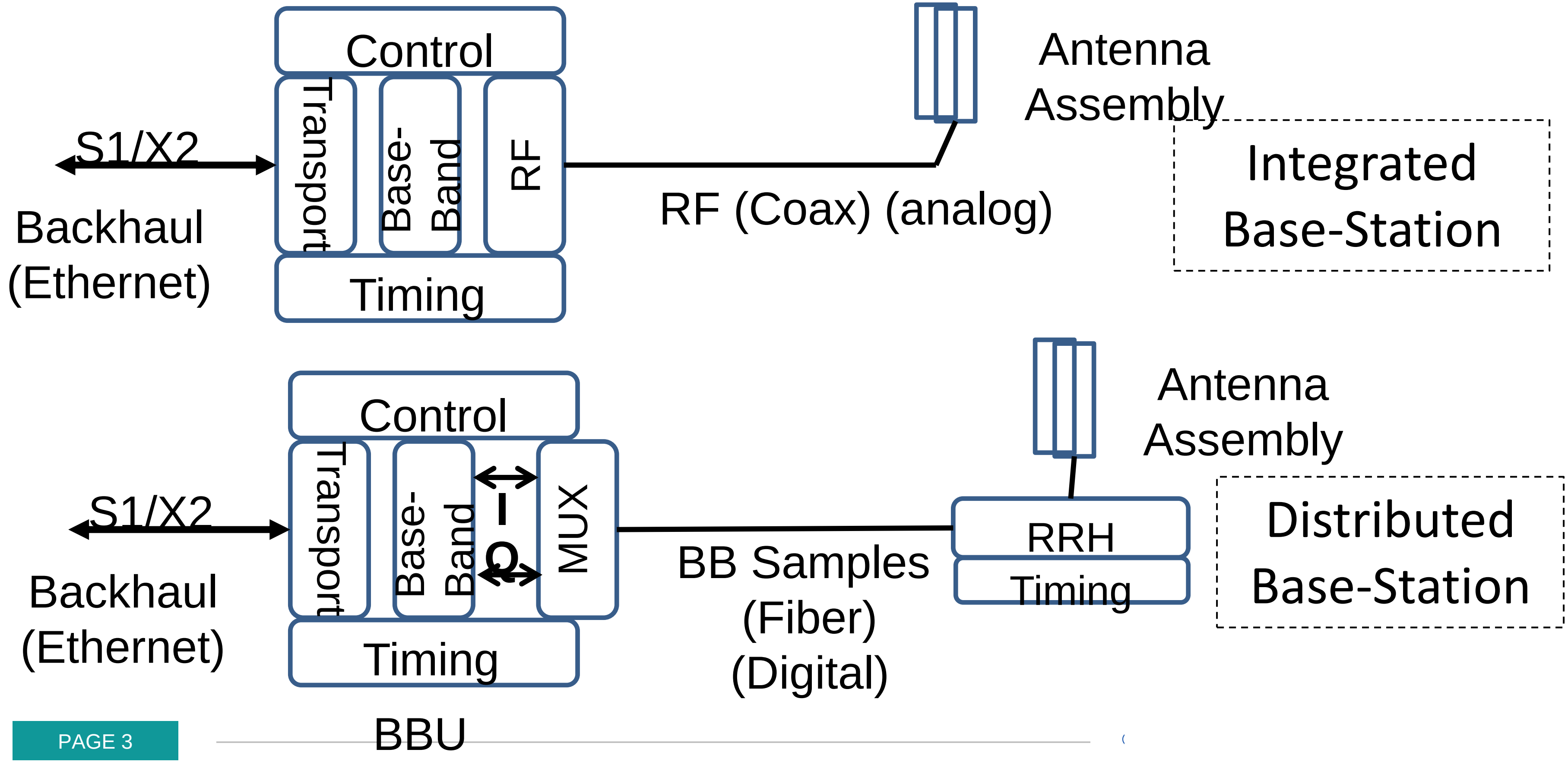
Outline of Presentation

- Evolution of a Base-Station
  - Integrated to Distributed
  - Considerations (time/frequency related)
- Evolution to a C-RAN architecture
- C-RAN and Small Cell deployments (synchronization perspective)
- Concluding Remarks
- Some Back-up Slides (FYI)

Evolution of a Base-Station



Important Considerations — 1

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- Integrated Base-Station:
  - RF signal generated in the integrated unit and fed over coax to antenna unit
  - Cable loss, time-delay, and frequency shaping are all a function of cable length (distance between electronics and antenna)
  - Good control of D/A conversion and modulation operation because of “single” clock in device

Important Considerations — 2

- Distributed Base-Station:
  - Base-Band Unit (BBU) generates the baseband version of transmit signal (In-phase and Quadrature signals) in digital format (typically 30.72MHz sampling rate, 15-bits/sample, per signal);
  - RF Signal attenuation and frequency shaping are not a function of cable distance between BBU and Remote Radio Head (RRH)
  - Need to transfer timing information from BBU to RRH
  - Time and frequency effects are still an important issue
    - Cable length introduces delay due to propagation
    - Clock regeneration adds wander/jitter

Important Considerations — 3

- Base-Band Signal: $\overline{x(nT_s)} = x_I(nT_s) + jx_Q(nT_s)$
- RF Signal:

$$w(t) = \hat{x}_I(t-\delta)\cdot cos(\omega_C t + \varphi_I(t)) + \hat{x}_Q(t-\delta)\cdot sin\left(\omega_C t + \varphi_Q(t)\right)$$

- Deleterious impact of delay (uncertainty):
  - In TDD mode this delay uncertainty necessitates greater inter-burst gap and therefore reduces bandwidth utilization
  - Some LTE features have reduced performance with increasing time error including: eICIC, CoMP, MBMS, etc.
- Deleterious impact of jitter and wander: not well documented but known to have negative impact on carrier as well as D/A conversion (affects SNR, BER, etc.)

Requirements

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Standard	Frequency	Phase	Remarks
3G UMTS	50 ppb	Not required	
CDMA	50 ppb	10 µs	Different standard
LTE-FDD	50 ppb	None	
LTE-TDD	50 ppb	±5 µs	
+ MBMS		±10 µs	On top of either LTE- TDD / LTE-FDD
+ eICIC		±5 µs	**Tighter sync results in better performance**
+ CoMP		±1.5 – ±0.5 µs	**Tighter sync results results in better performance**

Many diverse opinions

Tighter sync performance results in higher spectral efficiencies ➔ greater traffic carrying capacity

These requirements apply at the antenna (air interface)

Evolution to a C-RAN Architecture

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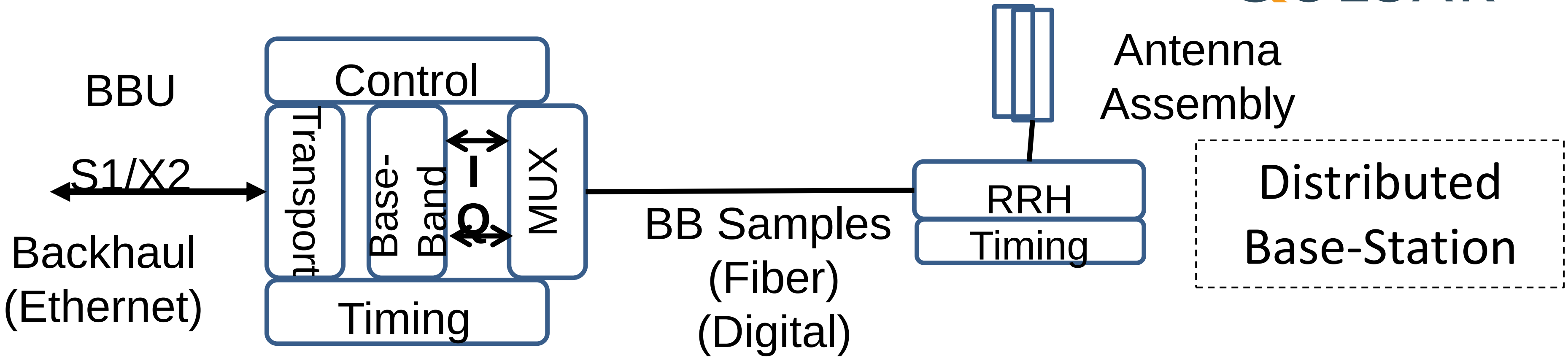

- Antenna system (RRH) can be disjoint from the BBU
- Given that the BBU-to-RRH link is suitably implemented, there is no stringent geographic linkage between BBU and RRH
- It is possible to co-locate multiple BBUs independently of the deployment of the (RF) antenna assembly
- C-RAN: antennas (RRH) located where the mobiles are; BBUs are located where building space (power, ground, air-conditioning, etc.) is available

Provided that the timing constraints (time/frequency) are satisfied

C-RAN Architecture

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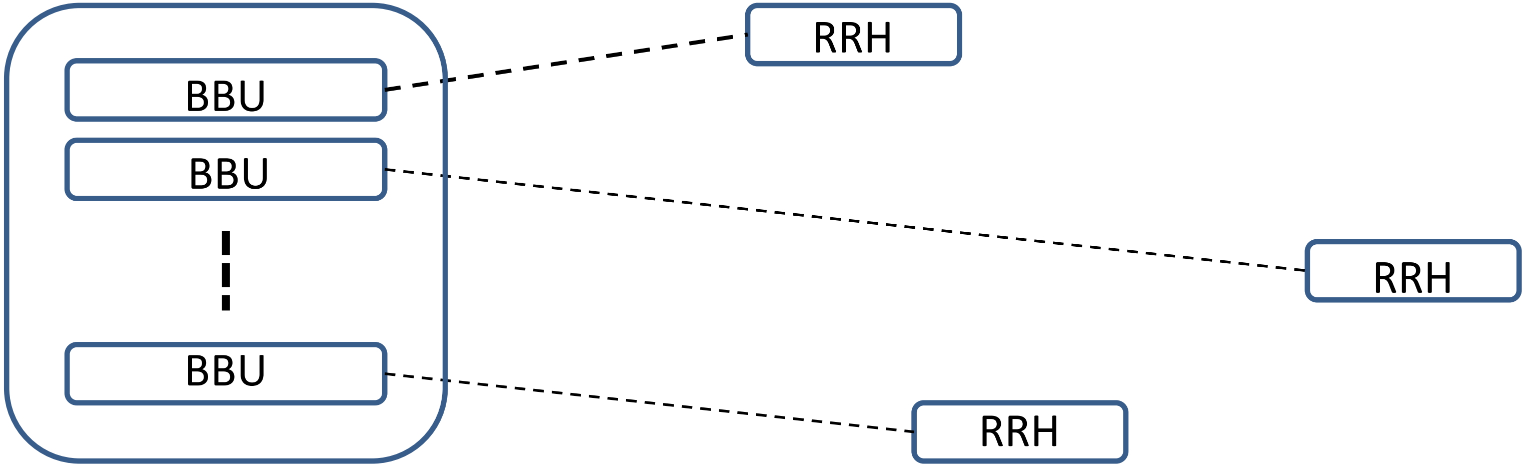
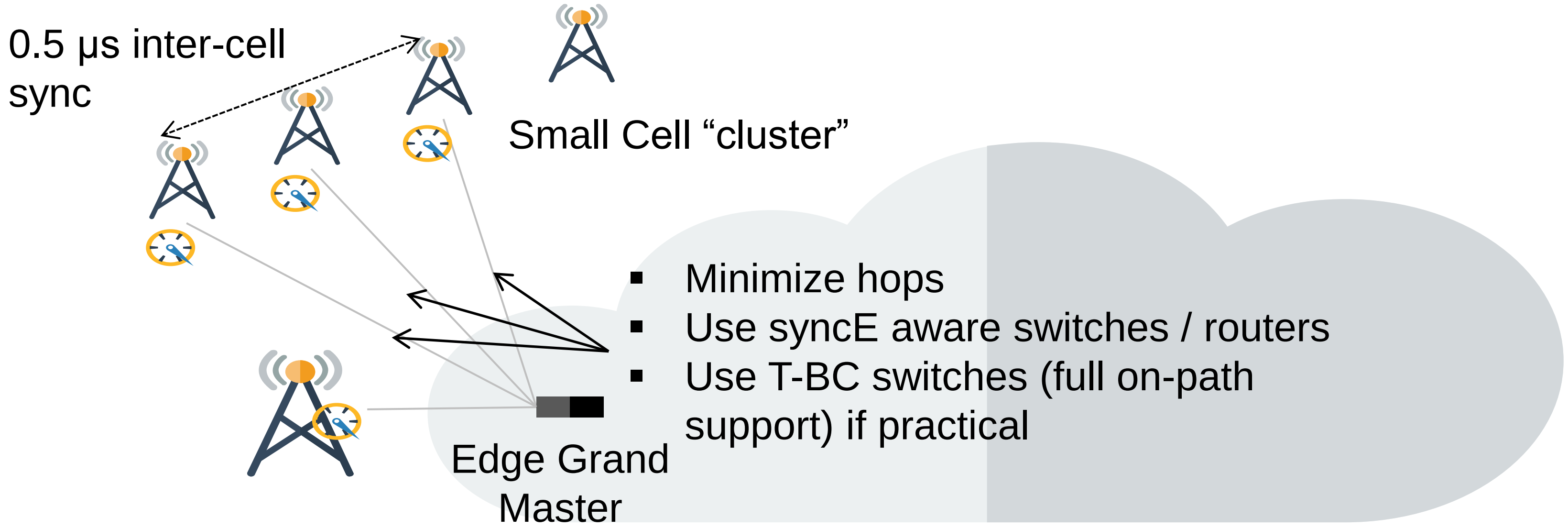


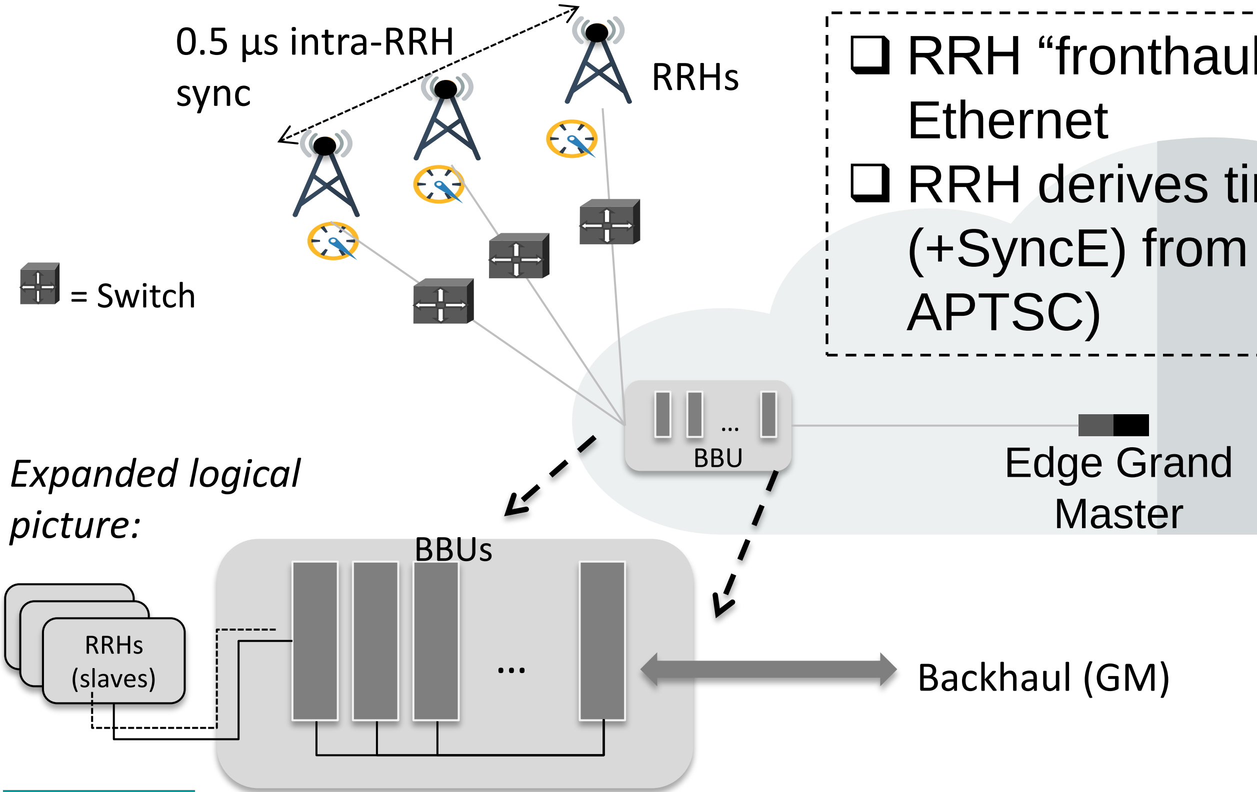
- Base-Band units (BBUs) are co-located and each BBU has a link to an RRH carrying the base-band signal samples
- RRH units are deployed according to cellular traffic needs
- BBU and RRH have to be (mutually) synchronized
- Functional split between BBU and RRH is a design choice
  - Latency and sync requirements depend on the functional split

Small Cells Synchronization



- Small Cell “backhaul” likely to be over Ethernet
- Base-station derives timing using PTP (+SyncE) from a close-in GM (could be APTSC)

C-RAN Synchronization



- RRH "fronthaul" likely to be over Ethernet
- RRH derives timing using PTP (+SyncE) from BBU (could be APTSC)

C-RAN (Small Cell) Synchronization

- Similar issues for synchronization in Small Cell and C-RAN deployment scenarios
- Boundary clocks in every BBU (C-RAN); Edge Grand Master (Small Cell)…. Limited number of hops between master-slave
- Hold-over oscillators deployed in BBU (CRAN) / Edge Grand Master (Small Cell)
  - End-points need to be inexpensive
- Synchronization requirement is the same for both RRH and Small Cell (e.g. 0.5us)
- Recommend BBU to RRH link switches support SyncE & T-BC if practical (same for EGM to Small Cell)

Supporting Test Results (G.8273.2)

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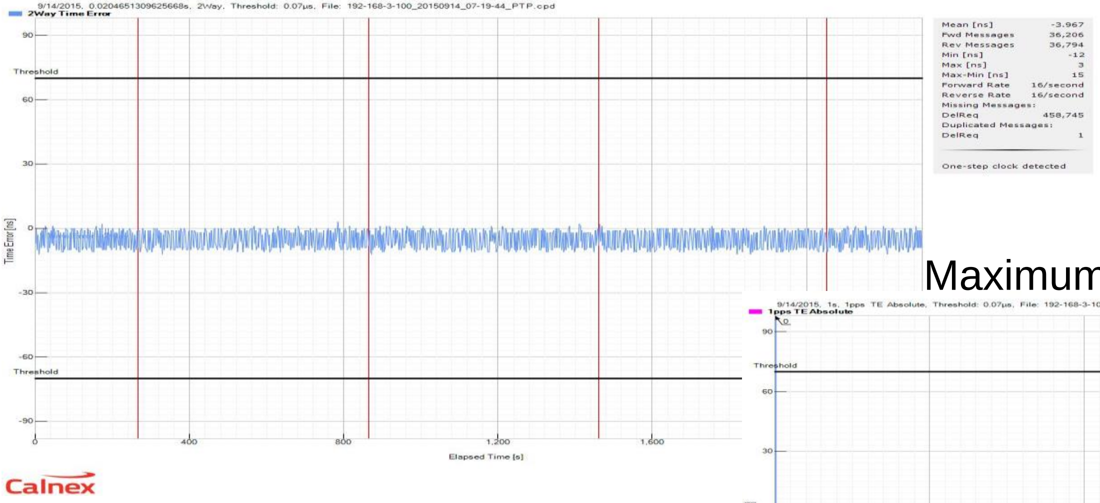
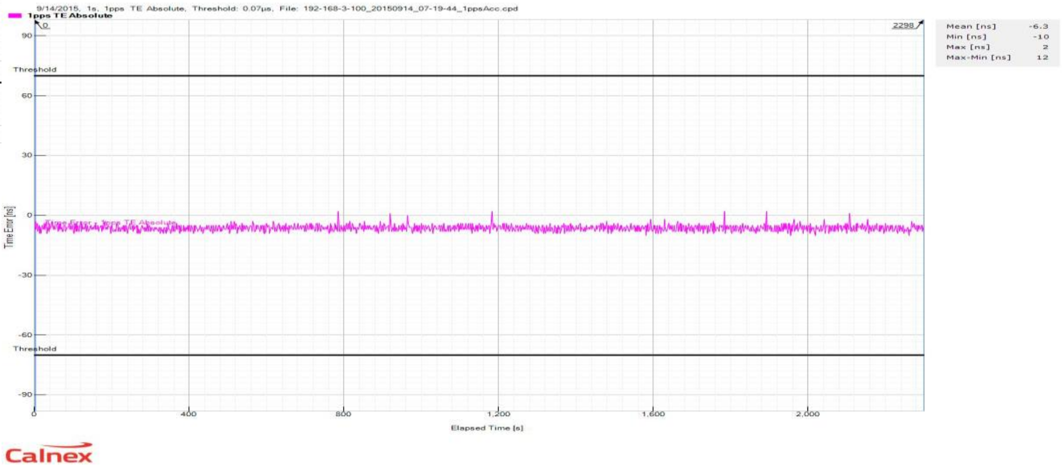
Maximum TE Results PTP



Maximum TE results PPS



Maximum time error behavior:

- 1pps output: 10 ns
- PTP output: 12 ns

Concluding Remarks

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- C-RAN architecture is a logical extension of a distributed base-station
- Timing (time/frequency) requirements at the radio interface are the same for C-RAN and Small Cell architectures
- Small Cell deployments are like distributed equipment; C-RAN corresponds to centralization of (most) equipment
- Timing distribution architectures are similar in C-RAN and Small Cell deployments

Questions?

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Back-up Slides

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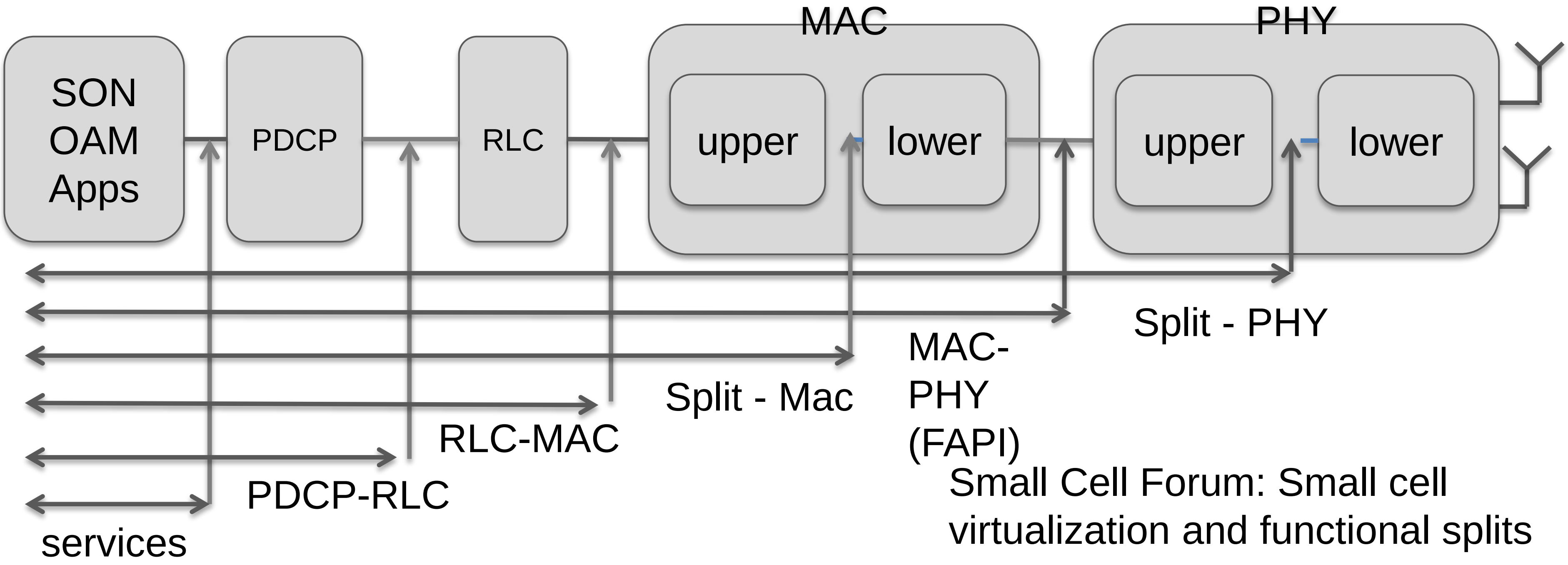
Use case architectures: BBU – RRH split



Small Cell Forum: Small cell virtualization and functional splits

Virtualized services on the BBU

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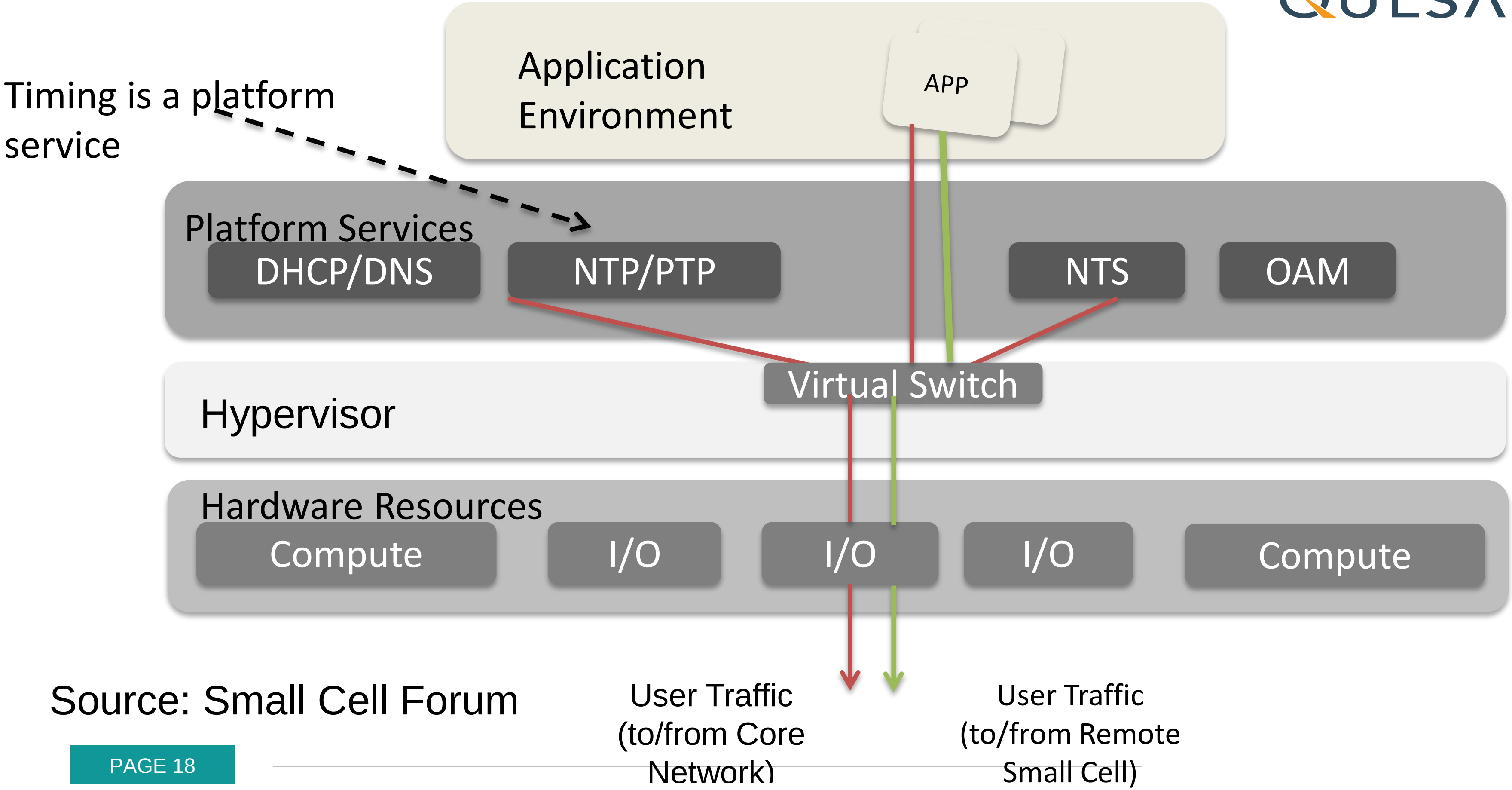

Source: Small Cell Forum

C-RAN survey results

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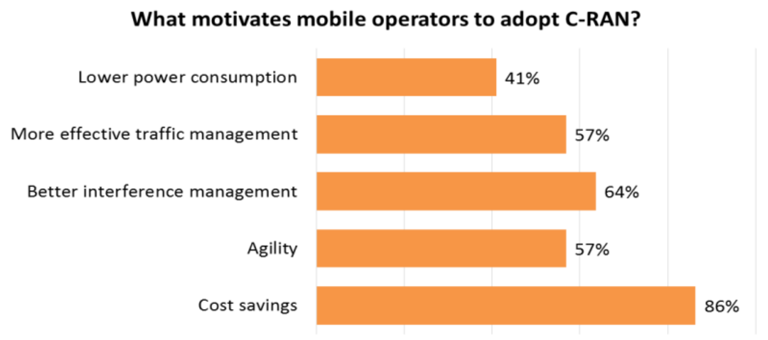
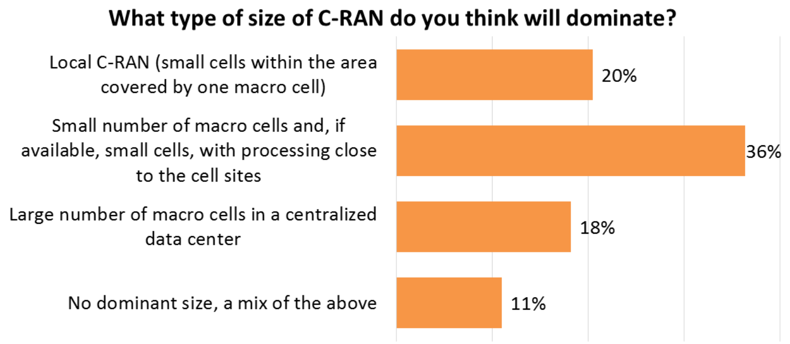
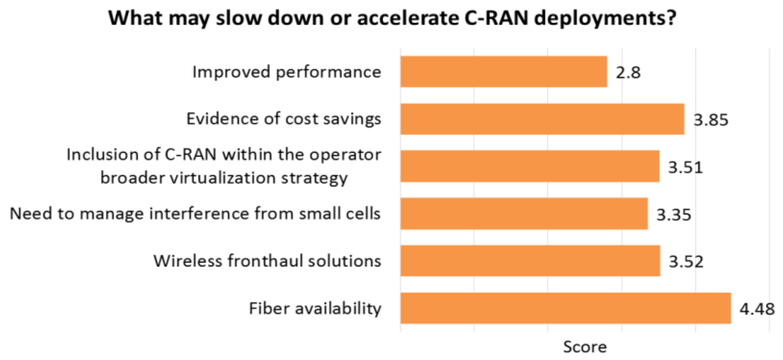


Cost savings are major motivation for C-RAN adoption
But yet difficult to assess cost savings in the long term



C-RAN and small cells strengthen each other value proposition



Fiber availability is still perceived as the major obstacle to C-RAN adoption

Courtesy: CRAN Webinar Sept 9'2015
Senza Fili Consulting LLC 2015