Changes, Challenges and Case studies in the fronthaul network for C-RANs

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Different C-RAN architectures

- Wide C-RAN
  - Macrocells + Hetnets

- Private and Local C-RAN
  - Micro or small cells
  - Outdoor: Local C-RAN
  - Indoor: Private C-RAN
C-RAN drivers

- Interest coming from network operational teams: **site engineering solution** due to increased network rollout difficulties
- **Antenna site simplification:** footprint reduction, renting cost reduction, reduced time to install
- Contribute to RAN strategies on tower sharing
- **Better radio performances:** thanks to very low latency between BBUs:
  - Better performance in mobility
  - Improved uplink coverage
  - Higher capacity and improved cell edge performance with inter-site CoMP
- **BBU pooling and aggregation gains** possible across a number of sites
- **Energy efficiency**
- **Future proof** for LTE-A and beyond
- In case of **hetnets:** **improved interference control**
- BBUs are in a secured location: **no need for IPSec**

**Drivers = cost reductions & ease of deployment**
Fronthaul trials drivers

- Save or built new sites which are identified by operational teams, as problematic in regular process (Distributed RAN with backhaul)
- Be compatible for a full site fronthaul swap: 2G, 3G and 4G (for all carriers) and 5G tomorrow
- Identify OPEX and CAPEX savings with existing Radio Access Technology equipment (2G, 3G, 4G)
- Initialize the learning curve of fronthaul network segment production: technologic choice, vendors pre-selection, installation process, Information System description, integration in the Operation Support System
- Measurements of Energy consumption
- Measurements, in a second step, of Data traffic impact (CoMP release)

Drivers = co-construction with operational teams
**Fronthaul**: a new segment that comes with Centralised Radio Access Network

**Fronthaul interfaces**: CPRI, OBSAI, ORI

**Fronthaul media**:
- Optical Fiber: Single Mode Fiber with or without color flavors
- Wireless: several RF bands possible with or without spectral efficiency
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Optical fronthaul (CPRI)

Passive

Active & Semi Active

Fiber-rich network

One/two fibers per CPRI link

Fiber-rich network to shared fiber

CWDM up to 18 channels

18 x up to 12 Gb/s (CPRI) = Max. 219 Gbit/s

Semi Active: transponder

Passive CWDM

Active: Transponder or Muxponder

Colorised

Two fibers and SFW SFP up to 36 CPRI

36 x up to 12 Gb/s (CPRI) = Max. 438 Gbit/s
Optical fronthaul (CPRI)

- Passive
  - Fiber-rich network
  - Solution selected for Micro site trials (one sector & several mobile carriers/generation)

- Active & Semi Active
  - Solution selected for Macro site trials (several sectors (typ. 3) & several carriers/generation)

- One/two fibers per CPRI link
- Shared fiber
What is a passive optical fronthaul solution?

- FTTA & PTTA hybrid cable
- Low foot print cabinet
  Energy and passive fiber
- Passive CWDM MUX & DeMUX

BBU Hotel
Data center area
for a cells cluster

Backhaul

Hardware sharing

BBU hotel
- BBU 2G
- BBU 3G
- BBU 4G

Interface fronthaul
Interface backhaul

optical fiber
Radio configuration vs. fronthaul configuration

- **Micro** sites configuration (one sector)
  - 2G: 900 & 1800 MHz
  - 3G: 2100 & 900 MHz
  - 4G: 2600, 800, 1800 MHz
  - Total: maximum 7 CPRIs
  - Mux/DeMUX: 8 wavelength channels with two fibers
  - SFP: CWDM outdoor compatible CPRI3 (ready to CPRI5), two fibers

- **Macro** site configuration (three sectors or more)
  - three times more CPRI links:
    - Total: 21 CPRI links and 3 more with coming 700MHz
  - Mux/DeMUX: 16 wavelength channels with two fibers
  - SFP: CWDM outdoor compatible CPRI3 (ready also to CPRI5), single fiber working (SFW)
    - SFP SFW allows to support 32 links with 16 CWDM channel pairs
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Wireless fronthaul (CPRI)

Native wireless

With spectral efficiency

From Small cell or 4th sector

to Macro cell

With wireless fronthaul, turn existing macro site into local C-RAN
Easier and faster deployment, same network architecture, better radio performance
Wireless fronthaul (CPRI)

Native wireless

2.5 Gbps CPRI in 500Mhz

1 LTE CPRI
1 x 2.5 Gb/s

mmwave (E-BAND)

Solution selected for trials (Mature solutions)

Other country than France should have better business case for wireless fronthaul
Wireless fronthaul: on Orange France network

Wireless fronthaul on Orange commercial network with FrontLink™ solution from E3Link

Three sectors LTE 2600 MIMO 2x2 → 3x2.457Gbit/s CPRI on a wireless fronthaul link

→ In less than 70 MHz bandwidth
Some use cases of wireless fronthaul

**Use Case:**
Optimized coverage with a macro sector

**Use Case:**
Improved coverage in VIP zones / Indoors
Macro, Micro or Repetear

**Use Case:**
Improved coverage in VIP zones / Indoors
## Conclusions and next steps (1/2)

| C-RAN drivers and global perspective | - Radio Site engineering solution & hardware sharing  
- Radio performance improvements and future proof for LTE-A  
- Hybrid Fronthaul/Backhaul solution needed to address **HetNets**  
- C-RAN to co-exist with regular RAN architecture |
| --- | --- |
| Wireless Fronthaul | - Wireless fronthaul **commercially available today** for network densification and **local C-RAN**  
- Use of millimetric bands in future for **massive small cells** |
| Fiber Fronthaul | - **CWDM ready**: simple, passive, cost effective and future proof  
- **CWDM single fiber working**: increase fiber sharing and operational simplification  
- **Transponder** if wavelength management is an issue  
- Supervision and OAM of fronthaul by RAN |
| Fronthaul | - RAN OSS to support fronthaul link (Fiber and wireless) |
| CPRI redefinition if needed | - CPRI transport: include natively the OAM of the medium  
- New functional split interface to reduce bandwidth?  
- Reference configuration including demarcation point  
- Sleep mode for energy efficiency?  
- Packetized fronthaul?  
- Why not Radio over Ethernet but do we want to include active transport equipment inside the RAN BBU-RRH links? |
Conclusions and next steps (2/2)

**New functional split**

- Multi-criteria issue
- One split per RAN vendors?
- No consensus between RAN vendors and SDO
- The existing CPRI is slightly vendor dependent but constant transport requirement

**Architectures**

- New functional splits could introduce several transport networks architectures
- Re-used existing backhaul equipment (switch, router,…) is not obvious
- Several QoS need to be manage
- Operators needs a simple and single (compatible with all RAN vendors) fronthaul architecture
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