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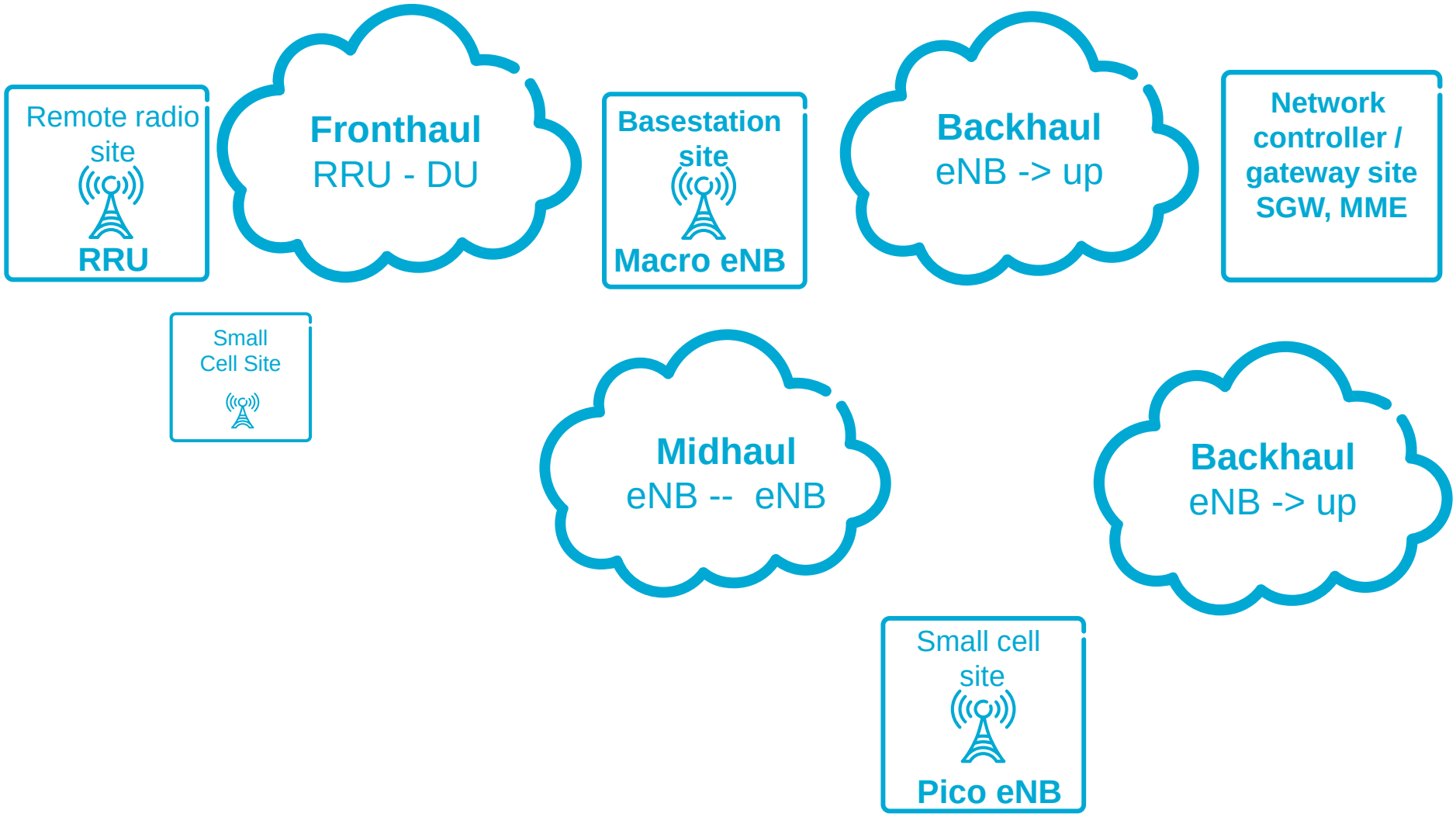
MOBILE NETWORKS:
TRANSPORT IMPACTS

September 2014

AGENDA

- Mobile networks transport
- CPRI Overview
- CPRI Transport Requirements
- CPRI over Ethernet – lab testbed
- Future Directions

FRONTHAUL, MIDHAUL & BACKHAUL



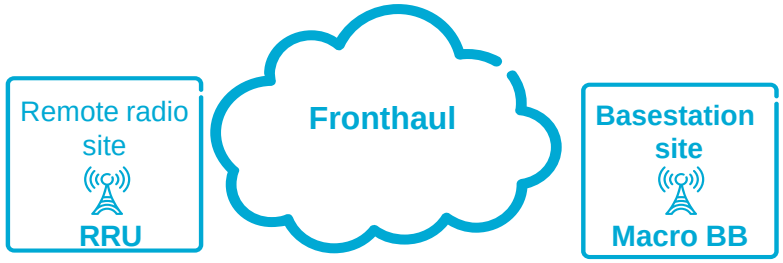
COMMON PUBLIC RADIO INTERFACE

- Separates Radio Equipment (RE) and Radio Equipment Control (REC) via CPRI link
  - Performance optimization drives RE and REC co-development
- CPRI interleaves Baseband (IQ) data with synchronization, control and management information.
- Focused on hardware dependent layers (layer 1 and layer 2), and is restricted to the link interface only.
- NOTE: CPRI was originally intended for very short distances, inside cabinet / at site.
  - Originally on electrical wire, now also over fibre.

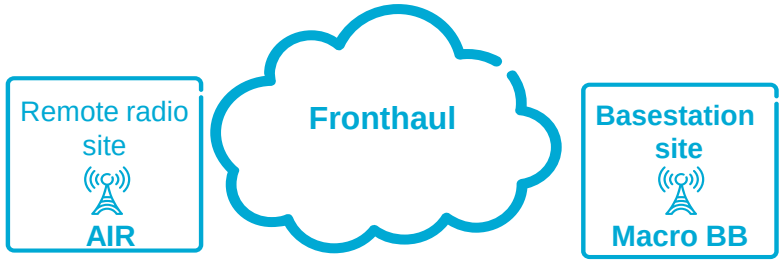
- http://www.cpri.info

NETWORKING TRENDS (1)

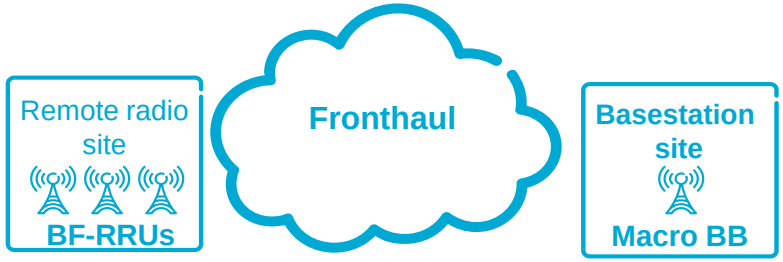
- **Main-Remote…**
  - Reduced feeder cabling
  - Smaller site footprint
  - Power saving at the RF feeder (3-6 dB)



- **Active Antennas…** already on the market.

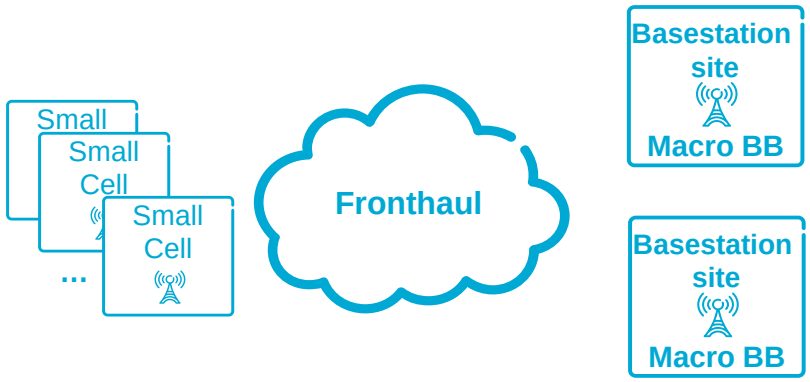


- **Beamforming Antennas…** standardization by 3GPP.

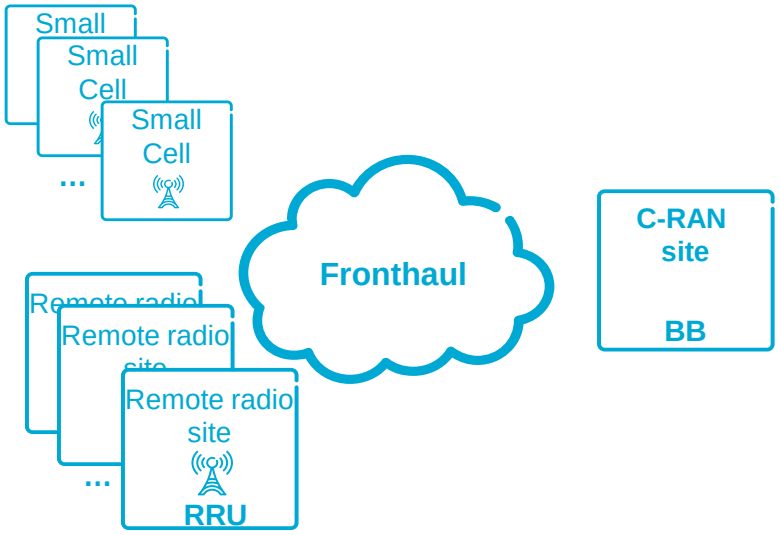


NETWORKING TRENDS (2)

› **Small Cells…** dense fronthaul network

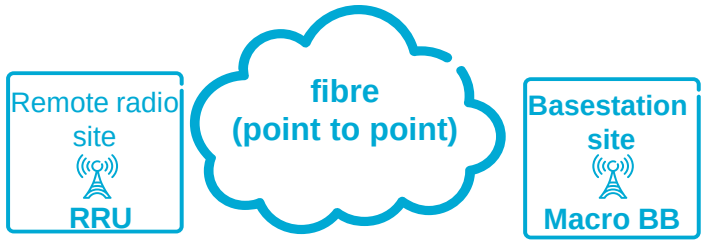


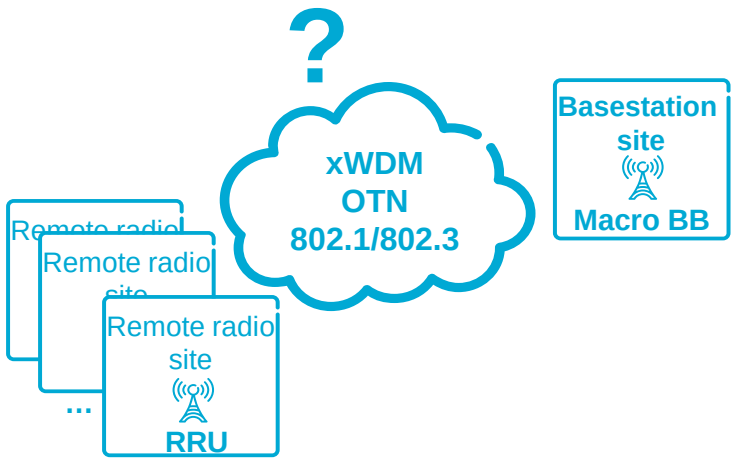
› **C-RAN…** centralized BB, extensive fronthaul network



FRONTHAUL EVOLUTION

- Fronthaul deployment has increased rapidly, from nearly nonexistent some few years ago to the preferred option.
- Fronthaul is likely to see higher demand.
- *But, fronthaul has stringent requirements!*
- 3 major possible paths…
  xWDM, OTN, Packet Networks



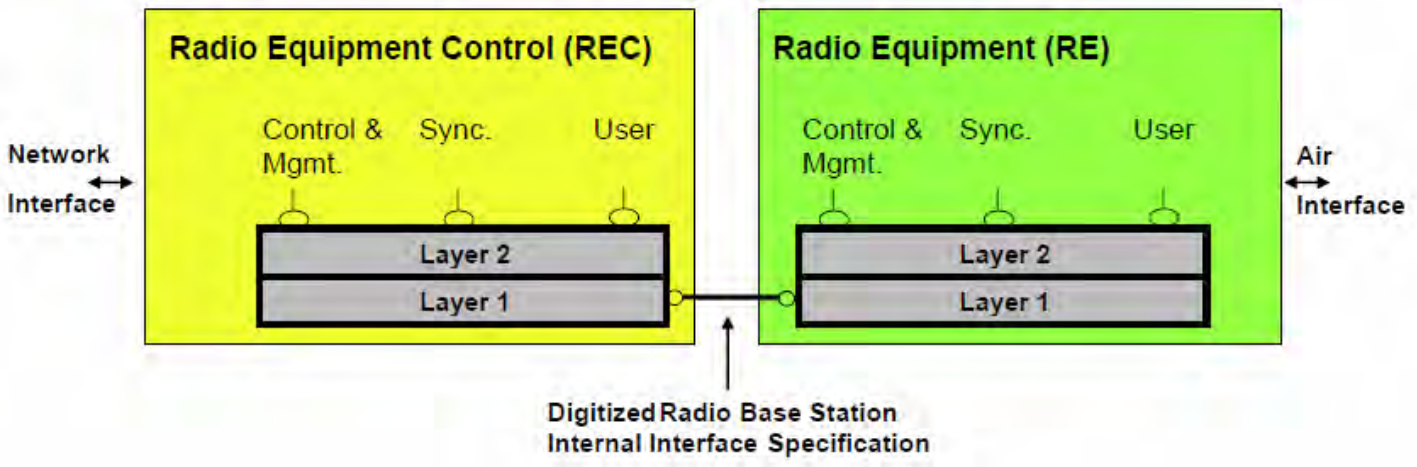


CPRI STRUCTURE

1. CPRI is a digitized serial internal radio base station interface between REC and RE

2. Three different information flows are implemented.
   1. User Plane.
   2. Control and Management Plane.
   3. Synchronization Plane.

3. The specification covers layers 1 and 2.
   - The physical layer (layer 1) supports both an electrical interface (e.g., what is used in traditional radio base stations), and an optical interface (e.g. for radio base stations with remote radio equipment).
   - Layer 2 supports flexibility and scalability.



CPRI TERMINOLOGY

- Basic Frame (BF) is the fundamental frame structure sent at a rate of 3.84MHz.

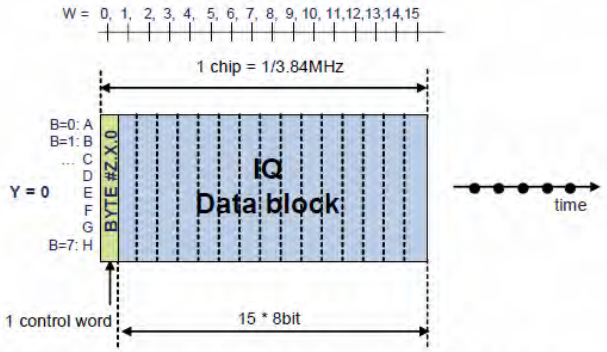


Figure 7: Basic frame structure for 614.4 Mbit/s CPRI line bit rate

- eNodeB Frame Number (BFN) is the radio frame number incremented every 10ms, used for network synchronization of the radio base station (RBS).
- The line bit rate of the CPRI link is a multiple of the BF rate:
  - CPRI line rate option 1: 614.4Mbps
  - CPRI line rate option 2: 1228.8Mbps
  - CPRI line rate option 3: 2457.6Mbps
  - CPRI line rate option 7: 9830.4Mbps

CPRI V6 REQUIREMENTS

- *Data rates ~1 – 10 Gbit/s*
  - *CPRI option 1-7*
- *Jitter-induced frequency error < 2ppb*
- *Link Time-Alignment-Error < 8.138 ns*
- *BER on user and C&M plane = 10^{-12}… No FEC*
- *Latency Budget ~50 usec (main-remote)*
  - *5us without cable length*

CPRI OVER ETHERNET – LAB TESTBED

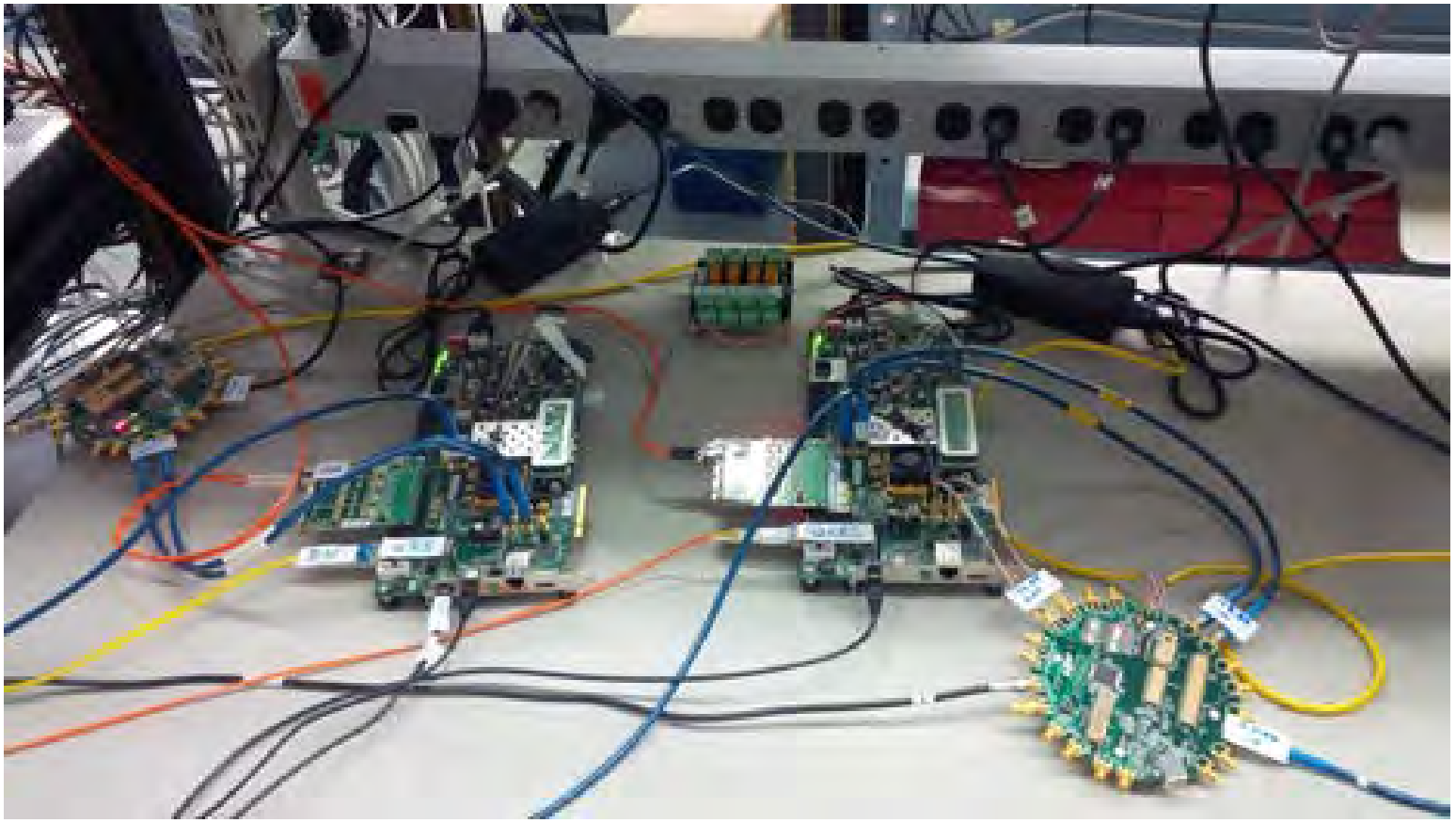
- All major players are experimenting with fronthaul testbeds
- Also testing out CPRI over Ethernet

10GE COE TESTBED

- REC/RE:
  - Commercial DU and RU
- aREC/aRE:
  - FPGA Evaluation Kit
  - Transport AxC0 … AxC15 of 2.5Gbps CPRI over 10GE
  - 16AxC's can represent 20MHz LTE 2x2 MIMO.
  - 8BF's encapsulated per CoE Packet
- Captive Switching Network:
  - 3x 10GE Switches

10GE TESTBED

10GE TESTBED aRE/aREC



COE KPI CHALLENGES

- Latency
  - ~ 5-15us per hop
  - Buffering needed to accommodate worst-case delay
- Sync Accuracy
  - Potentially >> 8ns, depending on transport topology, traffic conditions
- Transport Errors/Reliability
  - Dropped/delayed packets
  - BER
- Extremely high BW ... transport efficiency needed.

- *Cost Implications … CPRI is optimized to minimize cost of the end units (REC and RE). CoE increases cost/complexity.*

FUTURE DIRECTION

- *Fronthaul has stringent requirements as the active radio equipment in the RU is controlled via the CPRI link.*
  - *Cannot risk violation of requirements.*
  - *Not sufficient that it works in the lab.*

- *Mapping CPRI “per se” over Ethernet is an inefficient solution.*
  - *A better solution is to map I,Q & control data over Ethernet in an optimized way.*

FUTURE DIRECTION

- *Fronthaul developed by CPRI Group … Radio competence is essential*
- *IEEE 802.1/802.3 can contribute with Ethernet competence*
  - *Low latency, deterministic, lossless*
- *… Joint work with CPRI Group?*

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