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FRONTHAUL REQUIREMENTS FOR C-RAN

next generation mobile networks

FRONTHAUL REQUIREMENTS FOR C-RAN

BY NGMN ALLIANCE

DATE: 31-MARCH-2015

VERSION 1.0

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CONFIDENTIALITY CLASS	P-PUBLIC
PROJECT	C-RAN WORK STREAM, P-RAN EVO, PROJECT OF RAN EVOLUTION
EDITOR IN CHARGE	JINRI HUANG, QIXING WANG
EDITING TEAM	C-RAN WORK STREAM
DOCUMENT TYPE	FINAL DELIVERABLE (APPROVED)
APPROVED BY	APPROVED BY NGMN BOARD

Contents

SCOPE

This document specifies the requirements on fronthaul solutions which are essential to enable C-RAN deployment on a large scale.

In particular, this document addresses the requirements on the following aspects.

- Basic requirements;
- Performance
- Topology
- Reliability & QoS
- O&M
- Network sharing
- Miscellaneous

1 OVERVIEW OF P-CRAN

Featuring Centralized processing, Cooperative radio, Cloud computing and Clean target, the concept of Cloud RAN (C-RAN) was first proposed by China Mobile back in 2009. The new RAN architecture aims at helping operators to deal with various challenges such as increased TCO, deteriorated system performance due to severe interference, high energy consumption etc. thanks to traffic explosion in the era of mobile Internet [1]. C-RAN is a new RAN architecture with centralized DU (digital unit) nodes in which all computation/processing resource could be treated as a whole and therefore allocated on demand among different nodes. A basic illustrative concept of C-RAN is shown in Fig. 1. In order to realize and implement a truly advanced C-RAN, there are three stages to go.

- First, to centralize different DU nodes into the same site room to form a DU hotel.
- Then, a high-speed low-latency interconnection network enables different DU nodes to connect with each other with timely information exchange whenever necessary. In this way C-RAN could facilitate implementation of collaborative radio to reduce interference and improve system performance.
- Finally, all the computation resource from DU nodes are cloudized and could be allocated to or released from different nodes in a highly efficient and on-demand way. This is very similar to the cloud computing technology in a data centre.

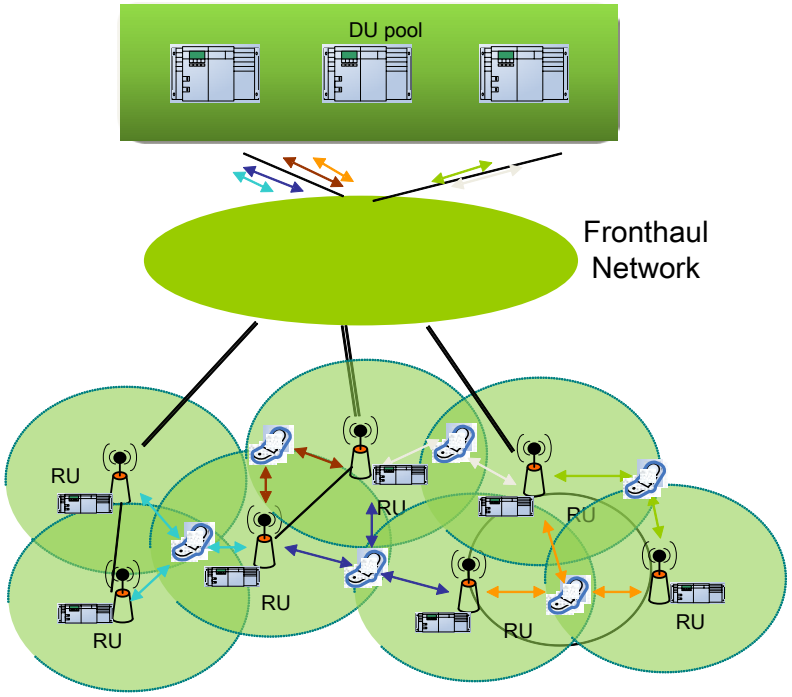

Figure 1: The concept of C-RAN

For more knowledge of C-RAN, readers are encouraged to refer to [1][2][3][4], from which the dedicated C-RAN activities as well as achievements in NGMN could be learned.

2 FIBER CONSUMPTION CHALLENGE BY CENTRALIZATION

Centralization is the critical first step required in order to realize all the features of C-RAN. Centralization aggregates different BBUs which traditionally are located in different geographical places into one central office with shared facilities. In practice, the scale of centralization is different from operator to operator due to their different resource conditions (e.g., the number of spare fibre).

Centralization scale of several dozens or several hundred carriers requires a large number of fibre resource if using dark fibre solution, i.e. direct fibre connection. For example, in a TD-LTE system with 20MHz bandwidth and RRUs equipped with 8 antennas (most common scenario in the CMCC network), the Common Public Radio Interface (CPRI) data rate between one BBU and one RRU for one TD-LTE carrier transmission is as high as 9.8Gbps. When considering both UL and DL, then 4 fibre connections would be required with 6Gbps optical modules. Since usually one site consists of three sectors with each supporting at least one carriers, the number of fibre connections for one site is as high as 12, which is difficult to achieve by most operators due to limited fibre resources. Even if 10Gbps SFP is used, to transmit one carrier still requires two fibre cores and one site of 3 carriers need 6 fibre cores. As a result, it is necessary to find a transport solution which can carry the information stream between DU pool and RU while consuming as few fibre resources as possible.

3 REQUIREMENTS ON C-RAN FRONTHAUL SOLUTIONS

The following terminologies are defined .

- Fronthaul link: A fronthaul link is the link between DU pool and a remote RU. Typical examples of fronthaul protocol include CPRI [5] and OBSAI (Open Base Station Architecture Initiative).
- Fronthaul network: A fronthaul network is a transport network which connects the DU pool and remote RRUs and is responsible for carrying the fronthaul links. One example of fronthaul network is a Wavelength Division Multiplexing (WDM) network.
- Fronthaul channel: A fronthaul channel is a channel inside a fronthaul network which is used to carry the fronthaul-related information, e.g. fronthaul links or relevant O&M messages.
- Fonthaul solution: A Fronthaul solution is a solution to fronthaul network realization. A fronthaul solution should meet the requirements specified in this document.

In the following, fronthaul will be abbreviated as FH for simplicity. The requirements on a FH solution go as follow.

Basic

[High priority] A FH solution should appear as an transparent transport channel when carring FH streams and therefore should be able to apply for various RATs, including 2G, 3G and LTE (including LTE-A).

[High priority] A FH solution must support CPRI and its relevant requirements, including timing, jitter, frequency offset, synchronization etc *.

(note: ORI is still of high interest to operators even though it is too early to mandate it for C-RAN)*

[High priority] A FH solution should support CPRI with option 2,3,4,5,6 and 7.

[High priority] A FH solution should be able to multiplex different FH links to transmit on the same channel. The same channel may or may not carry the O&M information in the FH domain.

Note: The multiplexing capability here means to multiplex different FH links in either eletrical or optical domain. Both, in principle are applicable. They can be done seperately or in combination, i.e.:

1. *Aggregation of different CPRI links in the electrical domain, e.g.*

   - *mapping/multiplexing of several CPRI carriers into a higher rate FH compound signal*

2. *Optical aggregation of CPRI links by wavelength multiplexing schemes (xWDM) of*

   - *Native CPRI links*
   - *Compound FH signals*

3. *The combination of 1. and 2.*

A typical example is to aggregate different links with smaller data rates (such as 2.5Gbps CPRI links) into one link with much higher data rate (e.g. one link of 10Gbps). Then the high data rate link could be mapped to one fronthaul channel (e.g. wavelength channel).

[High priority] The maximum supporting distance b/w DU and RU should be at least 20km.

[High priority] The one-way delay over the fronthaul network should be 250 microseconds or less. Note that this figure is intended as a future design goal dividing the available response times between the fronthaul networks and radio equipment processing. A more stringent delay requirement is preferred when fronthauling existing base station equipment (e.g. 45-100 microseconds one way depending upon the equipments).

[Low priority] A fronthaul solution may support CPRI option 8.

[Optional] The maximum supporting distance b/w BBU and RRU could be at least 50km.

[Optional] A FH solution may support CPRI option 1.

Performance:

[High priority] When fibre is used as the transmission media in a ring topology, then it is required that a pair of fibre should be able to carry at least 24 TD-LTE carriers with 20MHz BW&8X2 MIMO or 96 LTE carriers with 20MHz BW & 2X2 MIMO. Equivalently, it can be also that one fibre core supports 12 TD-LTE carriers with 20MHz BW&8X2 MIMO or 48 LTE carriers with 20MHz BW & 2X2 MIMO (*).

(Note: the CPRI data rate b/w DU and RU for a TD-LTE carrier with 20MHz BW and 8X2 MIMO is up to 9.8Gbps).*

[Optional] Bit error rate of the FH transport must be <=10^{-12}.

Topology

[High priority] Ring topology with fronthaul equipment is preferred in order to save fibre as much as possible.

Note: The topology here means the topology between fronthaul equipment. Due to the centralization nature of C-RAN networks, we envision for any fronthaul solution, there should be at least two types of fronthaul equipment. One is located in the central office together with (or at least close to) DU pool while the other is located in the remote connecting with remote RUs.

[High priority] Point to point and tree topology could be also supported to increase the network deployment flexibility.

Reliability & QoS

[High priority] A FH solution should provide 1:1 or 1+1 backup mechanism in case of fibre failure.

[High priority] When the fibre link breaks down and the FH network switches to the backup link, it is required that the link switch/recovery time be less than 50 ms.

[High priority] There should be no application-layer service interruption due to automatic line reverse in case of link failure.

O&M

[High priority] A FH solution should be able to provide basic O&M functions to the fronthaul networks, i.e. to provide management capability on FH network itself, including fault management, performance management, configuration management, real-time system status monitor, statistics report, alarm etc. with intuitive GUI interface.

Network sharing

[High priority] If fronthaul sharing is required by operators for support of RAN sharing, then the solution should possess the capability of addressing so that a RRU is able to serve multiple DUs.

Note: Some operators may have the need to share the same physical fronthaul network and RRU, while keeping their own BBU equipment. When only a single optical interface is available, the fronthaul network should be able to identify the input service and route them to different destination. Even if two or more optical interfaces on one RRU is realized by vendors, the same requirement is still valid when the number of operators who share a RRU exceeds the number of optical interfaces that the RRU provides.

Miscellaneous

[Low priority] A FH solution may support OBSAI and its relevant requirements.

[Optional] A FH solution could support bi-direction single fibre to further reduce fibre consumption.

[Optional] A FH solution may be multi-functional, i.e. in addition to support fronthaul transport b/w DU pool and remote RUs, the solution could also carry other various services, i.e. transport protocol, for example, MPLS-TP and G-PON.

4 CONCLUSION

Huge fibre consumption is always the first and the major concern for operators who are considering C-RAN implementation in their mobile networks. Therefore, an efficient and cost-effective fronthaul solution is essential for C-RAN deployment on a large scale. By publishing the fronthaul requirements, NGMN would like to call for more contribution and commitment on designing and realizing the FH solutions from the industry.

GLOSSARY OF DEFINITIONS AND TERMS

C-RAN	Centralized, Cooperative, Cloud and Clean RAN
CPRI	Common Public Radio Interface
DU	Digital Unit
FH	Fronthaul
RU	Radio Unit
O&M	Operation Maintenance

ORI	Open Radio Interface
WDM	Wavelength Division Multiplexing

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ACKNOWLEDGEMENTS

The authors of this document would like to thank the whole team of NGMN RAN EVOLUTION PROJECT for their great efforts and commitment which made the document come to reality.