Paper review on Mobile Fronthaul Networks

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Group Meeting, July. 14, 2017



- What is Mobile Fronthaul for 5G
- Fronthaul Transport Technologies
- MEC in Mobile Fronthaul
- Slicing of Mobile Fronthaul
- Summary



What is Mobile Fronthaul?

- Mobile Base-Station=Base Band Unit (BBU) + Radio Head (RH)
- Cloud-RAN(C-RAN): Centralized BBU pool + Remote Radio Heads (RRHs)
- RRH is the antennas sites with only RH functions
- Benefits offered by C-RAN: 1) inter-cell coordination, 2) down-sizing of antennas
- Mobile Fronthaul (MFH): intra-base station transport, used to connect BBU and RRH.





Issues of Mobile Fronthaul

- Common Public Radio Interface (CPRI): one alternative interface for MFH
- CPRI digitally transfers baseband signal, i.e. in-phase and quadrature (IQ) data, (CPRI uses OOK as modulation format), result in:
- 1) CPRI transmission needs huge bandwidth (more than 10 times the maximum speed of the wireless-communication)
- 2) CPRI' bandwidth is independent of the actual amount of traffic carried
- Massive small cell deployment, result in
- 3) huge number of optical fibers required

- 1. Optical links of 30 to 100 Gbps are required.
- 2. Constant bandwidth is consumed even when actual traffic is low
- 3. A huge number of opticalfibers are required. M-MIMO



Approaches for Mobile Fronthaul

• Re-definition of function split between BBU and RRH





Approaches for Mobile Fronthaul (cont.)

- Function Split alternatives
- Function split within PHY layer (State-of-art), e.g., CPRI, ORI
- RRU) A/D conversion and down/up-conversion; BBU) other processing functions
- (1) Function split between PHY and MAC
- BBU) MAC functionality, HARQ and FEC;
- RRU) modulation, precoding, other PHY functions
- (2) Function split between synchronous and asynchronous functions
- RRU) PHY, MAC and RLC related functions; BBU) PDCP and RRC functions

5G PPP Architecture Working Group, "View on 5G Architecture", [Online] Available:

https://5g-ppp.eu/wp-content/uploads/2014/02/5G-PPP-5G-Architecture-WP-For-public-consultation.pdf



Fronthaul transport technologies



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https://5g-ppp.eu/wp-content/uploads/2014/02/5G-PPP-5G-Architecture-WP-For-public-consultation.pdf

TDM-PON for Fronthaul

- Dynamic Bandwidth Assignment (DBA) in TDMA-PON systems.
- Optical Line Terminal (OLT) assigns bandwidth grants to each Optical Network Unit (ONU) according to bandwidth requests from ONUs.
- Issue:
- The assignment procedures result in a delay of around 1 ms, which may exceed the latency threshold of 5G wireless communications.
- Solutions
- Coordination between PON and RAN (Fronthaul)





TDM-PON for Fronthaul (cont.)

- Solution A:
- Accelerated burst scheduling of PON
- *T_{cycle}* : time for OLT to scan through all ONUs once (20µs preferred)
- *T_{burst}* : predetermined burst period for ONUs to transmit CPRI frames
- *Tgap* : to avoid implementation of imperfection-induced burst collision
- Flexible bandwidth allocation can be realized by assigning each ONU a given number of bursts per cycle



X. Liu and F. Effenberger, "Emerging optical access network technologies for 5G wireless [invited]," in IEEE/OSA Journal of Optical Communications and Networking, vol. 8, no. 12, pp. B70-B79, December 2016.

TDM-PON for Fronthaul (cont.)

- Solution B:
- Cooperative bandwidth assignment
- Delay-sensitive client system comprises Center node (BBU) and Remote node(RRH)
- It is assumed that BBU has information to estimate the amount of future upstream traffic from each ONU.
- The OLT implements an interface to receive this information from BBU to make accurate assignment in advance to the arrival of the traffic
- Minimizes delay in the TDMA-PON DBA section as well as the mis-assignment



J. i. Kani, J. Terada, K. I. Suzuki and A. Otaka, "Solutions for Future Mobile Fronthaul and Access-Network Convergence," in *Journal of Lightwave Technology*, vol. 35, no. 3, pp. 527-534, Feb.1, 1 2017.

T. Kobayashi, H. Ou, D. Hisano, T. Shimada, J. Terada and A. Otaka, "Bandwidth allocation scheme based on simple statistical traffic analysis for TDM-PON based mobile fronthaul," 2016 OFC, Anaheim, CA, 2016, pp. 1-3.



ARN for Fronthaul

- Co-locate ARN at macro cell sites
- ARN can serve carrier-grade Ethernet and mobile radio services jointly
- In uplink towards CO, WDM-PON is employed to use legacy fiber infrastructures



What is ARN??? Carrier-grade Layer 2 Ethernet Switch??





Where should MEC locate at in Fronthaul?

- MEC in PON-based Fronthaul
- MEC at ONU side?
- One important benefit of C-RAN is to down-size antenna equipment.
- To connect standard servers, full protocol stack should be equipped at ONU side. And this is opposite with the aim of C-RAN. Right?
- Is it possible to deploy MEC servers
 ONU-PeNB: Integrated ONU pico eNB
 at ONU side?



B. P. Rimal, D. P. Van and M. Maier, "Mobile Edge Computing Empowered Fiber-Wireless Access Networks in the 5G Era," in IEEE Communications Magazine, vol. 55, no. 2, pp. 192-200, February 2017.



Where should MEC locate at in Fronthaul?

- MEC for ARN-based Fronthaul
- ARN is a carrier-grade Ethernet switch that allows naturally the addition of storage and compute capabilities at network edge, nearest the radio links, and any other distributed network function that providers may want to develop.
- MEC can be deployed at ARN side, ARN side equipment with full stack will be more expensive.





E2E Slicing of 5G mobile networks

• E2E Slicing, including:

- (1) RAN slicing
- (2) MEC slicing
- (3) Mobile packet core slicing
- (4) Cloud Slicing



Goal : End-to-End Quality and Extreme Flexibility to Accommodate Various



Slicing of Fronthaul/BBU/MEC/Cloud

- (1) Slicing of PON-based Fronthaul?
- DBA for TDM-PON, slicing granularity is cell.
- (2) Slicing of BBU
- VNF configuration?
- (3) Slicing of MEC/Cloud
- VM provisioning, Workload assignment

RAN (Fronthaul) Slicing (Dynamic Resource Allocation for Small Cells)







- Function split point between RRU and BBU is a tradeoff between bandwidth and cost, and splitting between PHY-MAC is a promising choice.
- PON, especially TDM-PON is a good candidate for fronthaul transport.
- DBA of TDM-PON will result in unacceptable latency, and enhanced solution is required.
- The nearest location of MEC server is BBU side in PON-based PHY-MAC split fronthaul?
- E2E mobile network slicing need coordination among Fronthaul+BBU+MEC, or Fronthaul+BBU+Backhaul+Cloud.



Thank you!

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