TDM E-PON Front-haul Capacity Improvement Through Traffic Classification and Sifting

Post OFC Workshop

Yu Wu 03/27/2017



D TDM E-PON Front-haul Architecture

- Proposed Bandwidth Allocation Solution
- **Results**



- In 5G, Cloud Radio Access Network (C-RAN) is proposed to disperse the light-weighted radio equipment (a.k.a Remote Radio Heads (RRHs)) and centralize Base Band processing Unit (BBU). The connection between RRHs and BBU is called front-haul link and carried mostly by Common Public Radio Interface (CPRI).
- Dedicated Fiber between each RRH and paired BBU increases cost. Researchers have proposed to utilize multiplexing gain of TDM Ethernet PON (E-PON) to save cost.
- The proliferation of Internet of Thing (IoT) applications and deployment of Multiple Input Multiple Output (MIMO) antennas in RRHs increase fronthaul capacity demand and thus make multiplexing gain of TDM E-PON marginal.



- CPRI data compression techniques have been explored to address the problem of marginal multiplexing gain due to high CPRI line rate.
- Potential Drawbacks:
 - Computationally expensive (extra delays)
 - \circ Compression ratio up to 0.5
- The origin of our idea:
 - $\,\circ\,$ Mobile users do not communicate with RRHs all the time
 - RRHs do need to detect and sample all the time
 - Obtained data could be either useful or useless
 - $\,\circ\,$ Detect and discard useless data when transmitting at E-PON



D TDM E-PON Front-haul Architecture

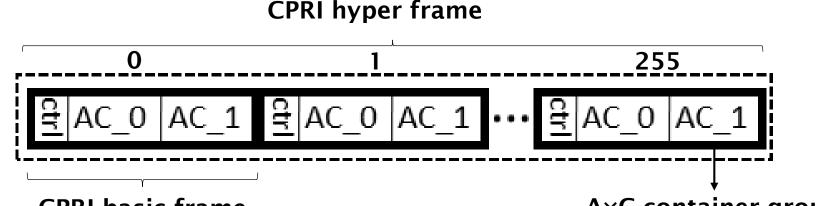
Proposed Bandwidth Allocation Solution

Results



TDM E-PON Front-haul Architecture

• CPRI basic frame and hyper frame



CPRI basic frame 16 words: 1 ctrl + 15 payload A×C container group

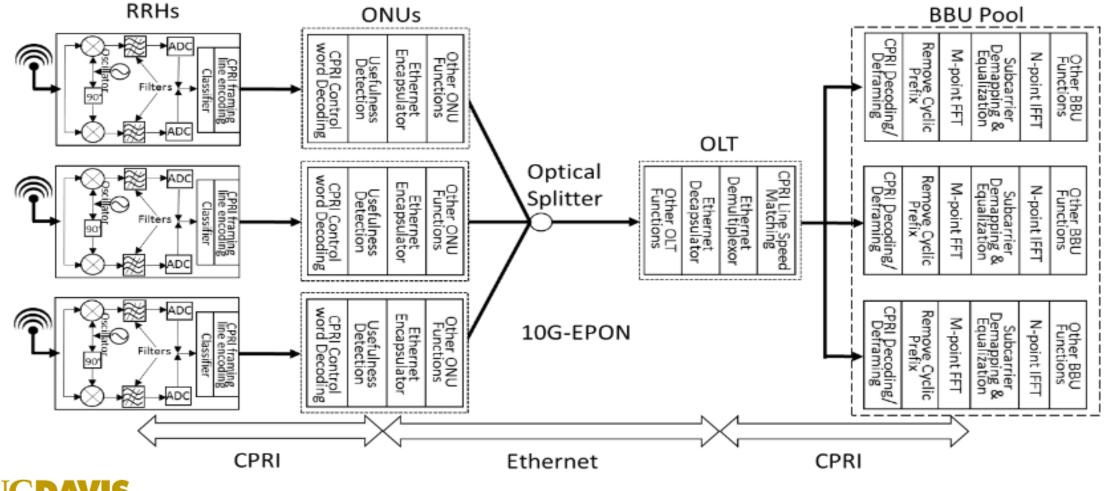
- Ethernet frame
 - Max payload: 1500 bytes
 - Header: 26 bytes
 - Inter-packet gap: 12 bytes

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Example:

- 20MHz 2×2 MIMO-enabled LTE RRH
- CPRI line rate: 2.46 Gbps
- CRPI word length: 32 bits
- Number of IQ samples per container group: 8

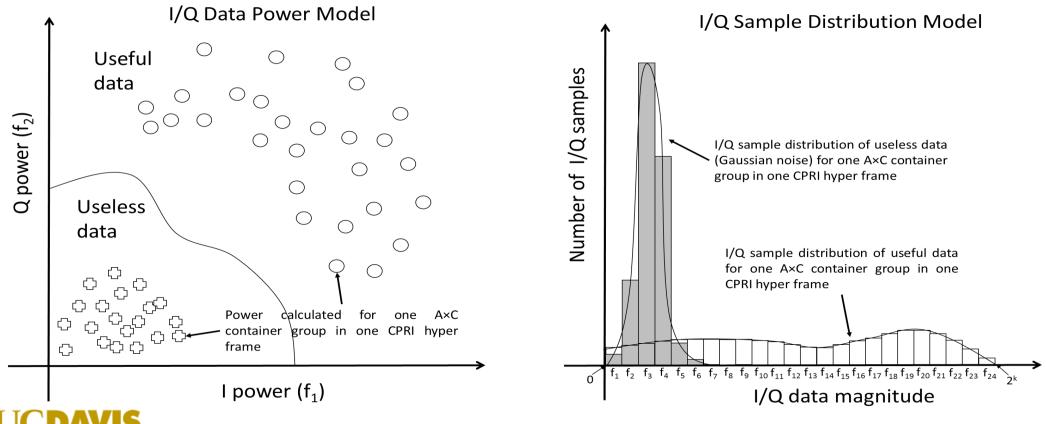
TDM E-PON Front-haul Architecture





TDM E-PON Front-haul Architecture

Traffic classification



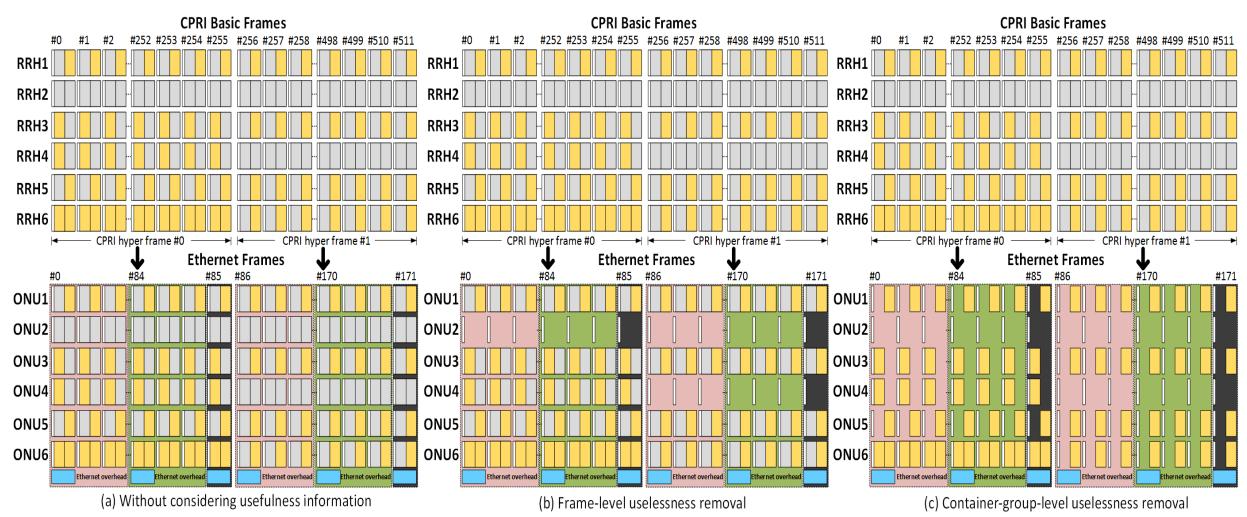


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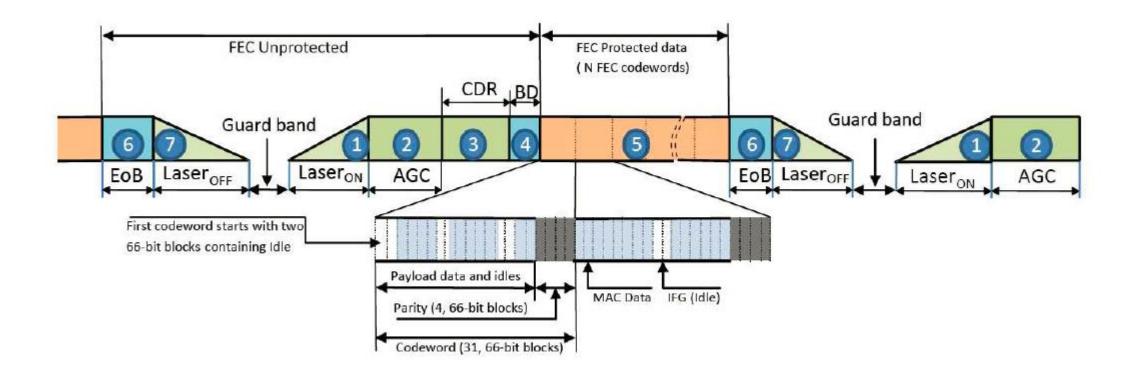
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Proposed Bandwidth Allocation Solution









Roy, Rajesh, et al. "10G-EPON efficiency." *Advanced Networks and Telecommunication Systems (ANTS).* IEEE, 2009.

Proposed Bandwidth Allocation Solution

| CPRI basic frame 0 - 2 | | |
|--|------------------------|--------------------------------|
| CPRI basic frame 3 - 5 | Ethernet Frame 0 | |
| | Ethernet Frame 1 | CPRI basic frame 0 - 2 |
| CPRI hyper | | CPRI basic frame 3 - 5 |
| frame #0 | | |
| CPRI basic frame 249 - 251 CPRI basic frame 252 - 254 255 | : | : |
| CPRI basic frame 256 - 258 CPRI basic frame 259 - 261 | | |
| CPRI hyper | Ethernet Frame 83 | |
| | Ethernet Frame 84 85 | CPRI basic frame 250 - 252 |
| frame #1 | Ethernet Frame 86 | CPRI basic frame 252 - 254 255 |
| | Ethernet Frame 87 | CPRI basic frame 256 - 258 |
| CPRI basic frame 505 - 507 CPRI basic frame 508 - 510 511 | | CPRI basic frame 259 - 261 |
| | : | : |
| | Ethernet Frame 169 | |
| | Ethernet Frame 170 171 | CPRI basic frame 505 - 507 |
| | F | CPRI basic frame 508 - 510 511 |
| , | | |

(a) Without considering usefulness information

| CPRI basic frame 0 - 2 | | |
|--|------------------------|----------------------------------|
| CPRI basic frame 3 - 5 | Ethernet Frame 0 | |
| | Ethernet Frame 1 | CPRI basic frame 0 - 2 |
| CPRI hyper | | CPRI basic frame 3 - 5 |
| frame #0 | ÷ | : |
| CPRI basic frame 249 - 251 | Ethernet Frame 54 | |
| CPRI basic frame 252 - 254 255 | Ethernet Frame 55 | CPRI basic frame 162 - 164 |
| CPRI basic frame 256 - 258 | Ethernet Frame 56 | CPRI basic frame 165 - 167 |
| CPRI basic frame 259 - 261 | Ethernet Frame 57 | CPRI basic frame 168 - 170 |
| | | CPRI basic frame 171 - 173 |
| CPRI hyper | Ethernet Frame 84 85 | |
| | Ethernet Frame 86 | CPRI basic frame 252 - 254 _ 255 |
| frame #1 | Ethernet Frame 87 | CPRI basic frame 256 - 258 |
| | 1 | CPRI basic frame 259 - 261 |
| CPRI basic frame 505 - 507 CPRI basic frame 508 - 510 511 | Ethernet Frame 116 | : |
| | Ethernet Frame 117 | CPRI basic frame 346 - 348 |
| | Ethernet Frame 118 | CPRI basic frame 349 - 351 |
| | Ethernet Frame 119 | CPRI basic frame 352 - 354 |
| | | CPRI basic frame 355 - 357 |
| | | |
| | Ethernet Frame 169 | • |
| | Ethernet Frame 170 171 | CPRI basic frame 505 - 507 |
| | | CPRI basic frame 508 - 510 511 |
| | , | , |

(b) Frame-level uselessness removal

| CPRI basic frame 0 - 2 | | |
|--|---|--|
| CPRI basic frame 3 - 5 | Ethernet Frame 0 | |
| | Ethernet Frame 1 | CPRI basic frame 0 - 2 |
| CPRI hyper | Lufemet Hame I | CPRI basic frame 3 - 5 |
| СЕКПУрег | | cr tr basic traine 5 - 5 |
| frame #0 | : | |
| france #0 | | : |
| CPRI basic frame 249 - 251 | Ethernet Frame 54 | |
| CPRI basic frame 249 - 251 CPRI basic frame 252 - 254 255 | Ethernet Frame 55 | CPRI basic frame 162 - 164 |
| CPRI basic frame 256 - 258 | | |
| CPRI basic frame 259 - 261 | Ethernet Frame 56 Ethernet Frame 57 | CPRI basic frame 165 - 167 CPRI basic frame 168 - 170 |
| | | CPRI basic frame 168 - 170 CPRI basic frame 171 - 173 |
| CDDL human | Ethernet Frame 8 <u>4</u> 85 | CPRI basic frame 252 - 254 255 |
| CPRI hyper | Ethernet Frame 86 | |
| frame #1 | Ethernet Frame 87 | CPRI basic frame 256 - 258 |
| frame #1 | • | CPRI basic frame 259 - 261 |
| | : | • |
| CPRI basic frame 505 - 507 CPRI basic frame 508 - 510 511 | Ethernet Frame 125 | • |
| CPRI Dasic Iraine 508 - 510 - 511 | Ethernet Frame 126 | CPRI basic frame 373 - 375 |
| | | CPRI basic frame 376 - 378 |
| | Ethernet Frame 127 Ethernet Frame 128 | CPRI basic frame 379 - 381 |
| | thernet Frame 169 Fthernet Frame 170 171 | CPRI basic frame 382 - 384 |
| | Ethernet Frame 170 171 | |
| | | CPRI basic frame 508 - 510 |
| | | CPRI basic frame 505 - 507 511 |
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(c) Container-group-level uselessness removal



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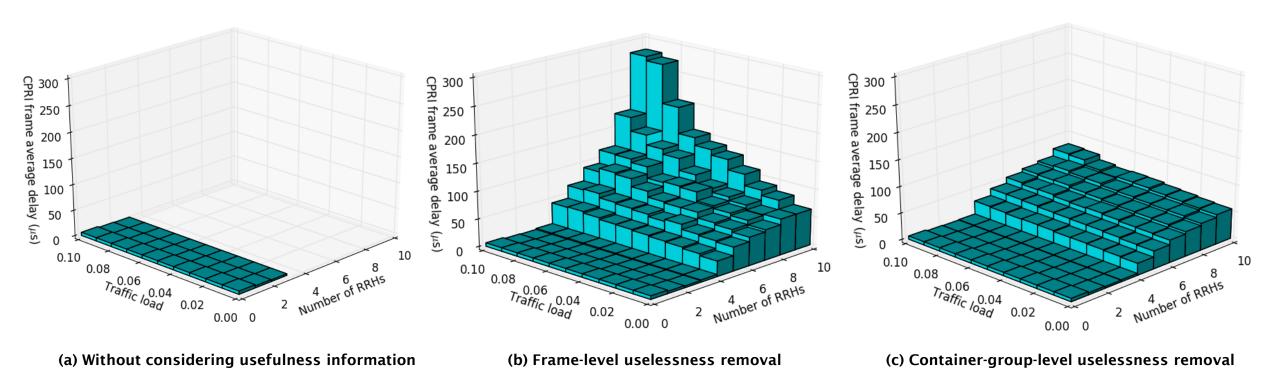
Proposed Bandwidth Allocation Solution

Results



Results

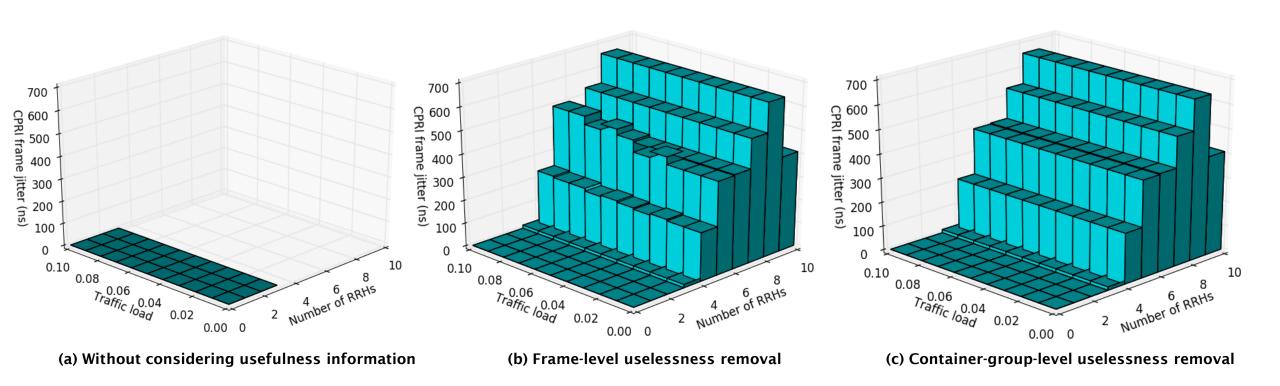
Delay





Results

Jitter





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- **Proposed Bandwidth Allocation Solution**
- **Results**



- Without traffic classification and sifting, the number of RRHs attached to the same E-PON is small.
- Container-group-level uselessness removal performs better than frame-level uselessness removal in terms of CPRI frame average delay when traffic load and number of RRHs increase.
- Both mechanisms achieve similar jitter performance.



Thank you for your attention !

Questions and feedbacks are welcomed

