Support for eCPRI in 802.1CM

Getting Started

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Disclaimer

- This presentation should be considered as the personal views of the presenter/author (largely based on former work on packet transport for the I_{ub} interface of UTRAN).

Contents

References

[1] Common Public Radio Interface (CPRI) Interface Specification V7.0, October, 2015, http://www.cpri.info/spec.html

[2] eCPRI Specification V1.0, August, 2017, http://www.cpri.info/spec.html

[3] Requirements for the eCPRI Transport Network D0.1, August, 2017, http://www.cpri.info/spec.html

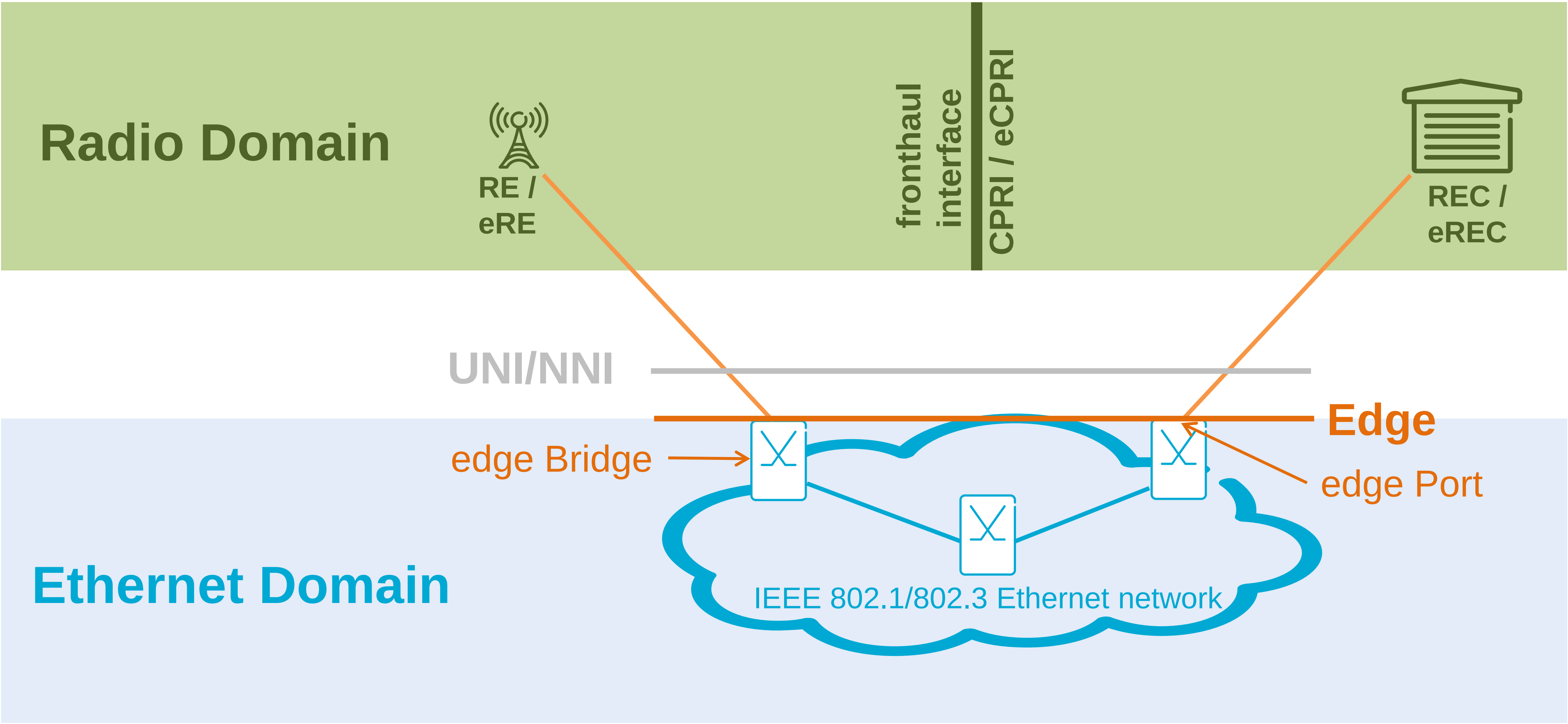
[4] Tongtong Wang, Xinyuan Wang, “Consideration of FLR in TSN for Fronthaul,” contribution to P802.1CM, September 2016, http://www.ieee802.org/1/files/public/docs2016/cm-wangtt-FLR-consideration-0916.pdf

Notations

- RE: CPRI Radio Equipment
- REC: CPRI Radio Equipment Control
- eRE: eCPRI Radio Equipment
- eREC: eCPRI Radio Equipment Control
- CIR: Committed Information Rate
- EIR: Excess Information Rate

- Class 1
  - Corresponds to the classical CPRI [1] split, which is referred to as Split E in [2] for E-UTRA (Evolved Universal Terrestrial Radio Access)
- Class 2
  - Corresponds to Split $\{I_D;II_D;I_U\}$ of [2] for E-UTRA, i.e., split within the PHY layer

Recap

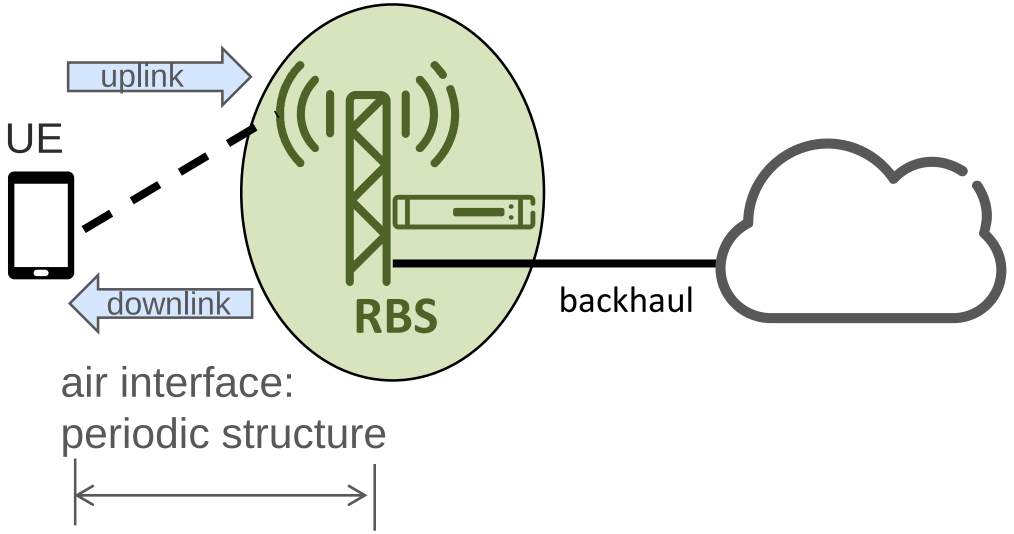


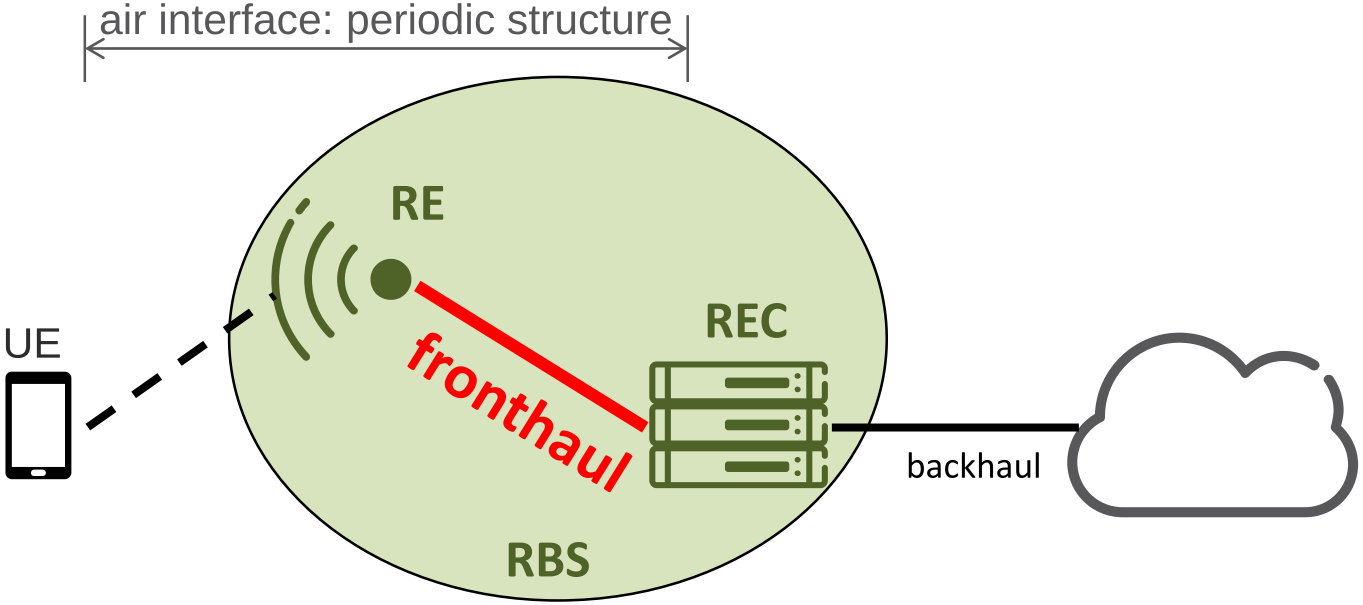
Radio Domain
RE / eRE
fronthaul interface
CPRI / eCPRI
REC / eREC
UNI/NNI
Edge
edge Bridge
edge Port
IEEE 802.1/802.3 Ethernet network
Ethernet Domain

Traffic Model

Periodic Framing Structure on Radio Interface

- Ultimately, the framing is periodic on the air interface, i.e., radio samples are periodic
- Air interface traffic samples transmitted via fronthaul
  - **Class 1**
    CPRI IQ data traffic is CBR, not correlated with the traffic of the User Equipment (UE)
  - **Class 2**
    User Data is correlated with UE traffic
    (e.g., (approximately) no data transmitted via fronthaul if UE does not transmit/receive data)

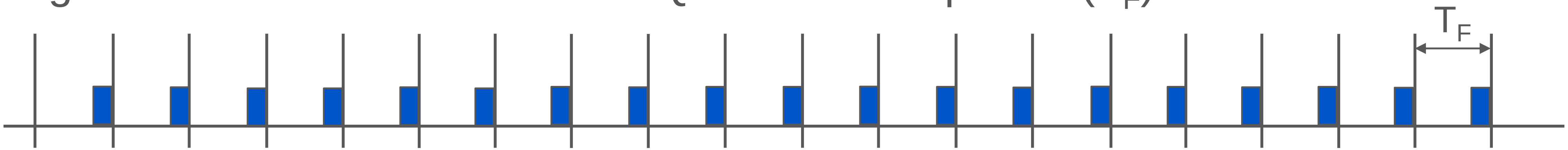


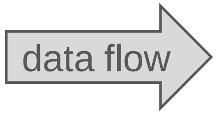


Class 1 User (IQ) Data Traffic at the Edge

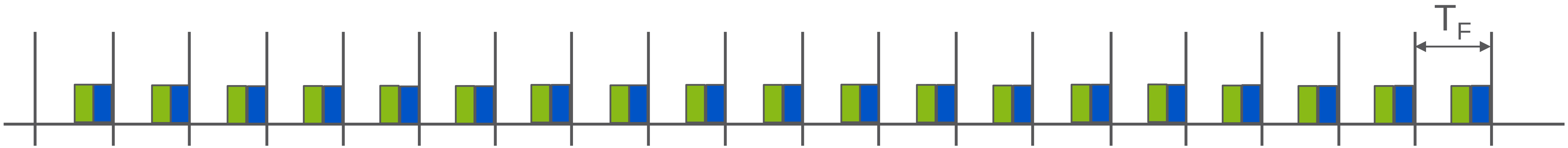
- IQ data is CBR: same amount of data is sent in each period (Fronthaul period: T_F)
- Maximum possible IQ Data in one Ethernet frame = 1500 Bytes (e.g., for worst-case calculations)

a) Single Ethernet frame carries the IQ Data of one period (T_F)



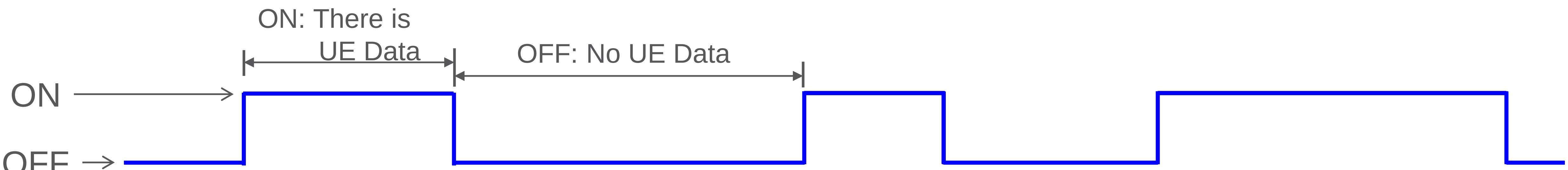


b) Multiple Ethernet frames carry the IQ Data of one period (T_F)

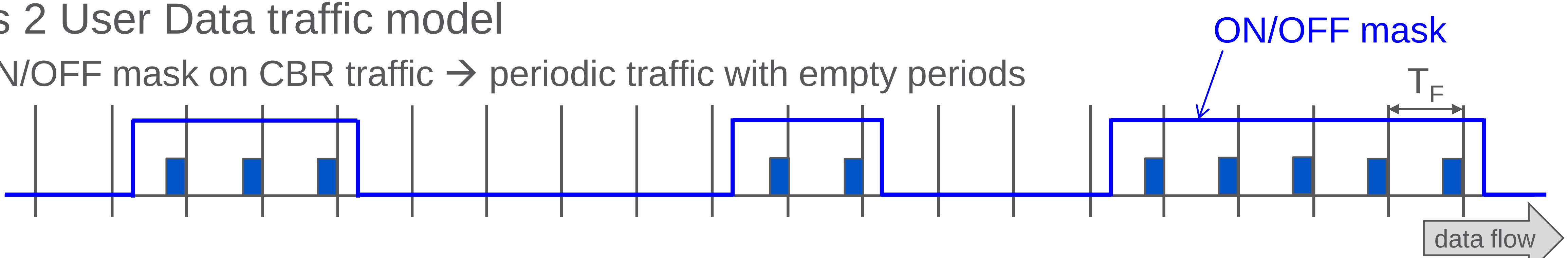


Class 2 User Data Traffic at the Edge

- This slide provides a high level starting point, details elaborated on the following slides
- User Equipment (UE) traffic



  - Note: no strict rules on how long ON and OFF last
- Class 2 User Data traffic is correlated with UE traffic
- Class 2 User Data traffic model
  - ON/OFF mask on CBR traffic → periodic traffic with empty periods

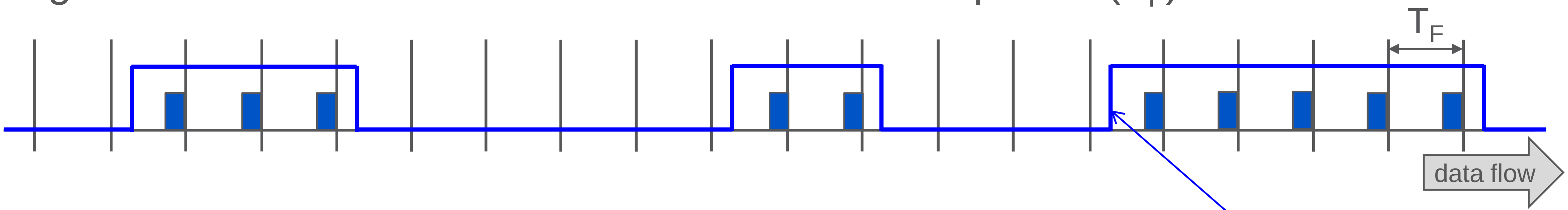


  - Still valid: user data of one period (T_F) may be carried in multiple Ethernet frames

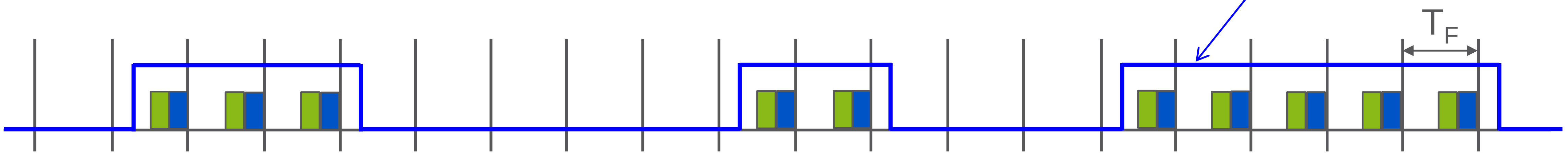
Uplink Class 2 User Data Traffic at the Edge

- ON/OFF masked periodic traffic with fixed amount of data in each period, if any
- Maximum possible User Data in one Ethernet frame = 1500 Bytes (e.g., for worst-case calculations)

a) Single Ethernet frame carries the User Data of one period (T_F)

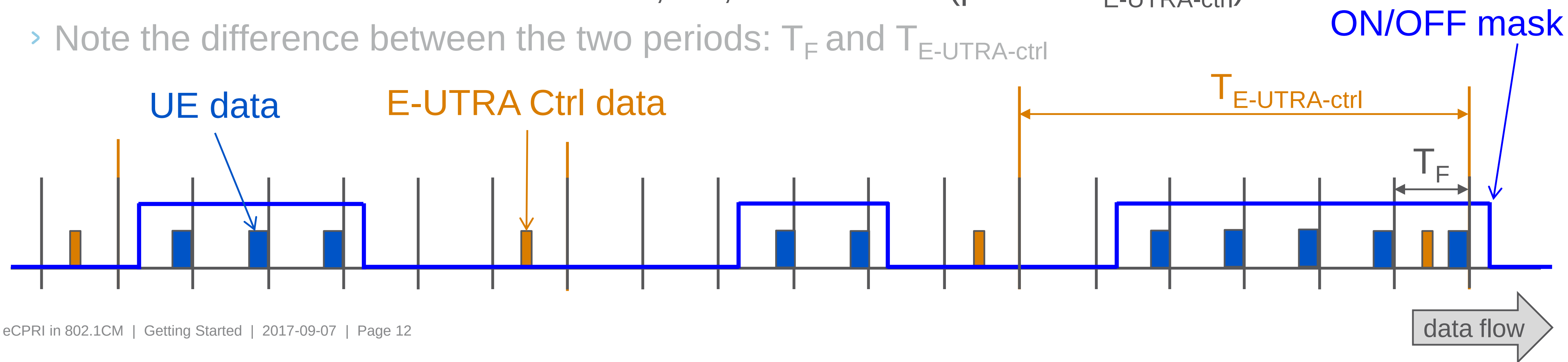


b) Multiple Ethernet frames carry the User Data of one period (T_F)



Downlink Class 2 User Data Traffic at the Edge

- Downlink Class 2 User Data Traffic may have two components, e.g.,
  - UE data
    - ON/OFF masked periodic traffic with fixed amount of data in each period, if any
    - Maximum possible UE data in one Ethernet frame = 1500 Bytes
    - UE data of one period (T_F) may be carried in multiple Ethernet frames (not illustrated here)
  - E-UTRA control channel data (real-time control data [2])
    - Periodic traffic with fix amount of data, i.e., classic CBR (period: $T_{E\text{-}UTRA\text{-}ctrl}$)
    - Note the difference between the two periods: T_F and $T_{E\text{-}UTRA\text{-}ctrl}$



How to support Class 2 (eCPRI) in 802.1CM?

Recap: Support for Class 1 (CPRI)

- Requirements for Class 1 User (IQ) Data
  - maximum end-to-end One-way Frame Delay = 100 µs (no requirement on Frame Delay Variation)
  - maximum Frame Loss Ratio = 10^{-7}
- Profiles A and B are engineered taking into account the worst-case in order to meet the requirements → e2e delay < 100 µs for each IQ Data frame
- Edge Bridges ensure that the traffic does not exceed for what the engineering was done
  - MEF 10.3 Ingress Bandwidth Profile can be used
  - Committed Information Rate (CIR) corresponds to engineering results to meet delay req
  - Excess Information Rate (EIR) = 0
  - Each Class 1 User (IQ) Data frame admitted to the network is green, no yellow frames
  - Only bit errors contribute to FLR
    - Probability{loss due to bit error} = $6.6*10^{-8}$ up to 200 GbE [4] (denoted Pr{BER} here)

Two Approaches to Support Class 2 (eCPRI)

- Approach 1
  - Bridged network is engineered as if Class 2 User Data was CBR like Class 1 User Data
    - Engineering for CIR
    - EIR = 0
  - Other traffic can use the bandwidth not used by Class 2 User Data
- Approach 2
  - Admit more Class 2 User Data such that delay and loss requirements are still met
    - CIR corresponds to engineering results to meet delay requirement
    - EIR > 0 → some frames are marked yellow, which may be dropped → contributes to loss
    - Pr{yellow marking} + Pr{BER} < Max FLR
    - With Max FLR = 10^{-7}, Pr{yellow marking} < $3.4*10^{-8}$ (Pr{BER} = $6.6*10^{-8}$ [4], see p14)
    - Relaxing Max FLR would give more room for yellow marking, i.e., better bandwidth efficiency
  - Other traffic can still use the bandwidth not used by Class 2 User Data

Discussion

- Should we add Approach 1 or Approach 2 to 802.1CM?
- Or a 3rd one?

Further Notes

One-way Frame Delay in MEF 10.3

- The One-way Frame Delay for an egress Service Frame at a given UNI in the EVC is defined as the ***time elapsed from the transmission at the ingress UNI of the first bit*** of the corresponding ingress Service Frame ***until the reception of the last bit of the Service Frame at the given UNI***.
- Note that this definition of Frame Delay for a Service Frame is the one-way delay that includes the delays encountered as a result of transmission of the Service Frame across the ingress and egress UNIs as well as that introduced by the CEN.

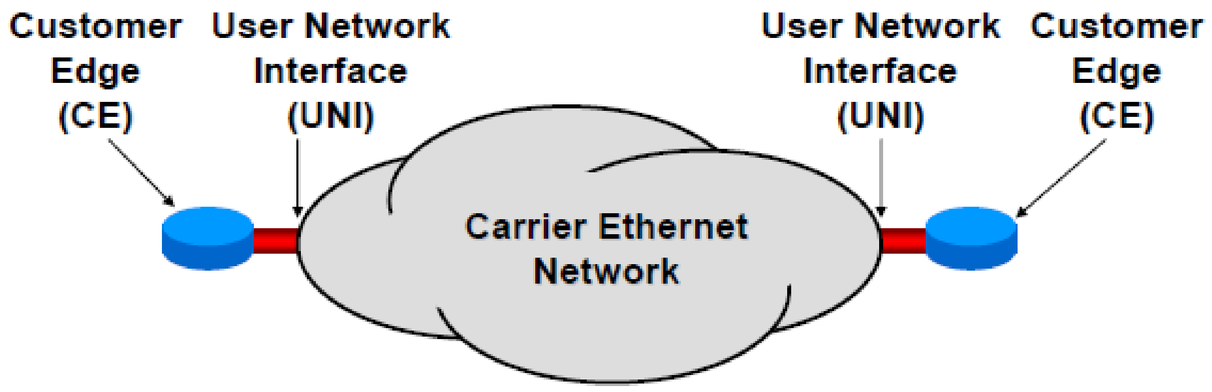


Figure 1 – Ethernet Services Model

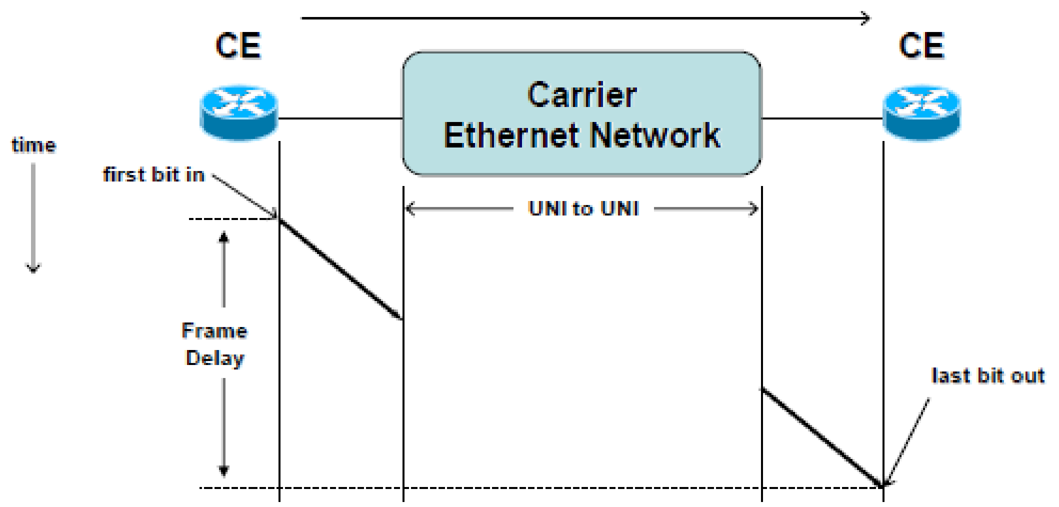


Figure 9 - Frame Delay for Service Frame

One-way Frame Delay in MEF 10.4 (approved draft)

- The One-way Frame Delay for a Service Frame that ingresses at UNI_1 and results in a Service Frame that egresses at UNI_2 is defined as the ***time elapsed from the reception of the first bit of the ingress Service Frame at UNI_1 until the transmission of the last bit of the first corresponding egress Service Frame at UNI_2.***

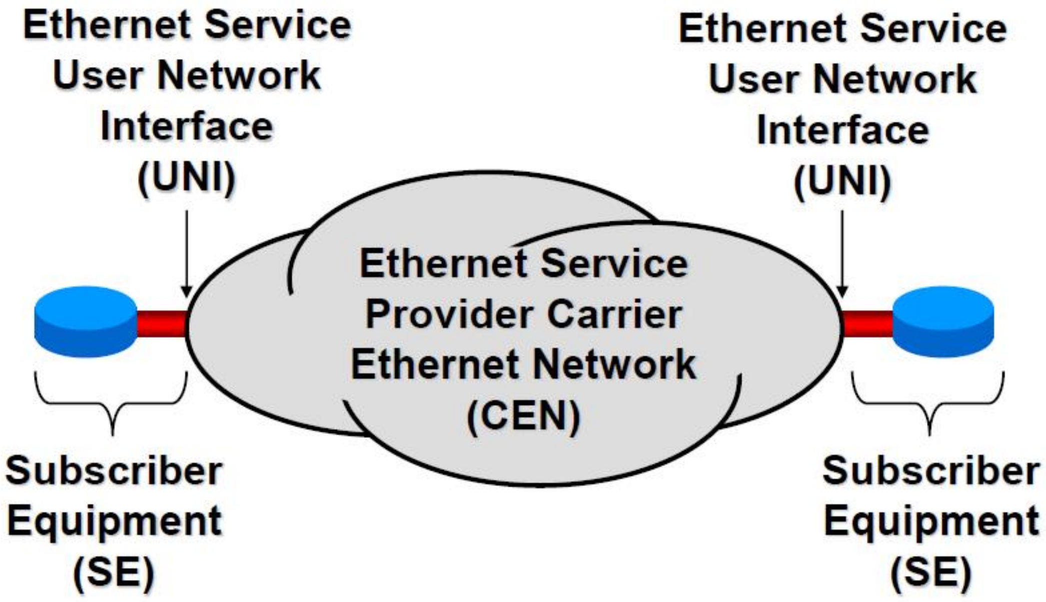


Figure 1 – Fundamental Model

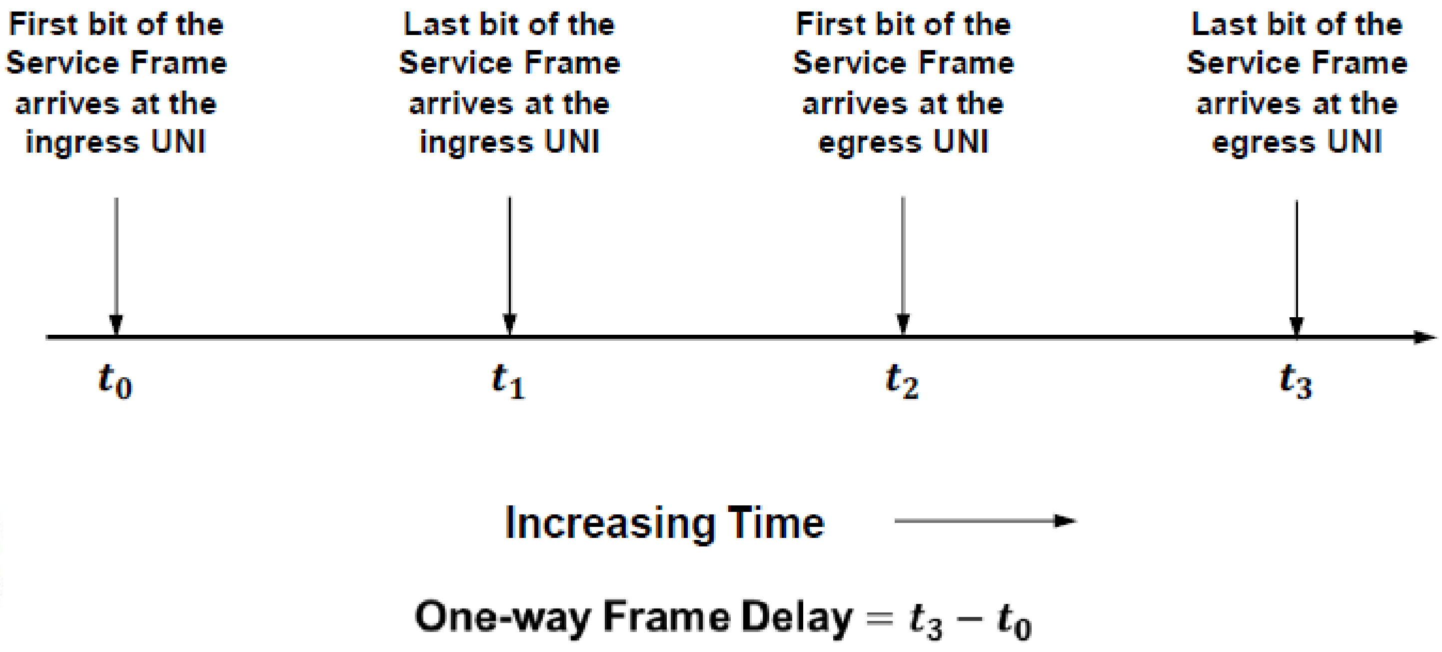


Figure 15 – One-way Frame Delay for Service Frame

https://www.mef.net/Assets/Liaison/Aug-01-2017/D00134_001_MEF_10.4_AD_1_Klessig.pdf

One-way Frame Delay in P802.1CM D0.7

- The end-to-end one-way latency is measured from the arrival of the last bit at the ingress edge Port of the bridged network to the transmission of the last bit by the egress edge Port of the bridged network (see, e.g., Annex L.3 in IEEE Std 802.1Q-2014).

- Suggestion
  1. Keept it as is
  2. Or at most change “last bit” to “first bit” at the ingress Port