Considerations on synchronization in next generation CRAN fronthaul architecture

Lv Bo, Hu Changjun, Lu Yang

CAICT

Compliance with IEEE Standards Policies and Procedures

Subclause 5.2.1 of the *IEEE-SA Standards Board Bylaws* states, "While participating in IEEE standards development activities, all participants…shall act in accordance with all applicable laws (nation-based and international), the IEEE Code of Ethics, and with IEEE Standards policies and procedures."

The contributor acknowledges and accepts that this contribution is subject to

- The IEEE Standards copyright policy as stated in the *IEEE-SA Standards Board Bylaws*, section 7, http://standards.ieee.org/develop/policies/bylaws/sect6-7.html#7, and the *IEEE-SA Standards Board Operations Manual*, section 6.1, http://standards.ieee.org/develop/policies/opman/sect6.html
- The IEEE Standards patent policy as stated in the *IEEE-SA Standards Board Bylaws*, section 6, http://standards.ieee.org/guides/bylaws/sect6-7.html#6, and the *IEEE-SA Standards Board Operations Manual*, section 6.3, http://standards.ieee.org/develop/policies/opman/sect6.html

IEEE WG1914
NGFI
Jinri Huang, huangjinri@chinamobile.com

[Considerations on synchronization in next generation CRAN fronthaul architecture]

Date: 2016-08-17

Author(s):

Name	Affiliation	Phone [optional]	Email [optional]
Lv Bo	CAICT	+86-18601309707	lvbo@caict.ac.cn
Hu Changjun	CAICT		
Lu Yang	CAICT	+86-18510550580	luyang@ritt.cn

Overview

Traditional CRAN fronthaul architecture with CPRI interface

- The link is always online with TDM scheme;
- Frequency & Phase Synchronization between BBU and RRU are easy to be solved under peer to peer scenario with direct fiber connection;
- Synchronization performance index: ± 2ppb frequency accuracy and ±65ns time accuracy.

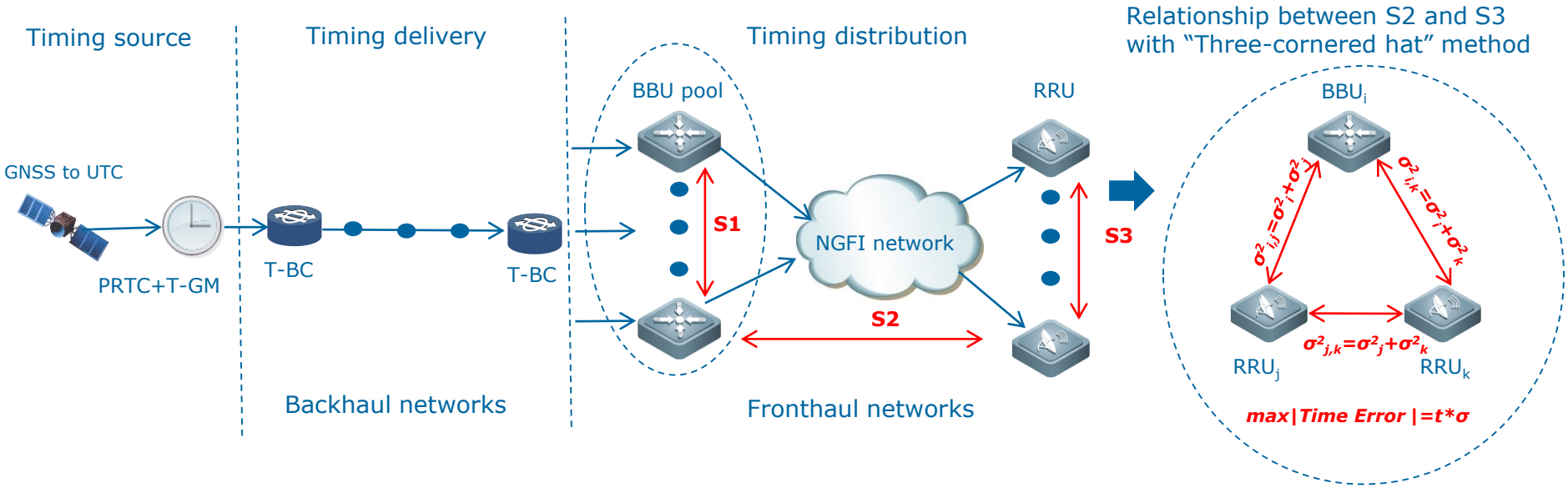
Next Generation CRAN fronthaul architecture with NGFI interface

- Data are transmitted Statistical multiplexing with Ethernet;
- Nodes are synchronized over Ethernet to take advantage of idle period to make power consumption earth-friendly;
- Under packet switching network Synchronization performance may suffer from PDV(Packet Delay Variance) and will be more challenging;
- Initial discussion on how to support synchronization for NGFI in ITU-T.

Considerations for synchronization

Three Time&frequency errors are considered in next generation CRAN fronthaul architecture on timing distribution

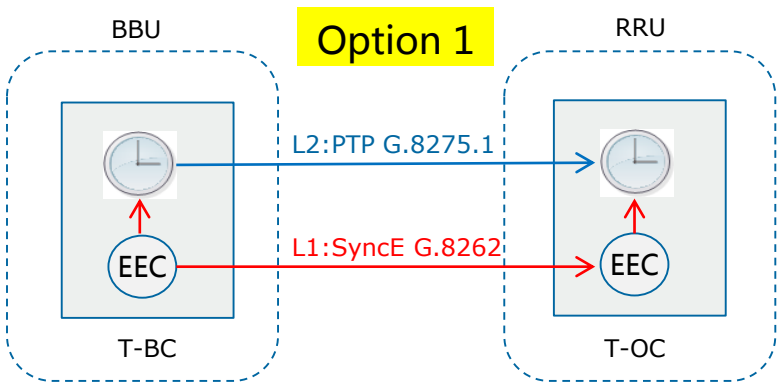
- S1(BBU to BBU)is distributed in backhaul architecture solved in ITU-T G.8271.1 HRM;
- S2(BBU to RRU)is suggested as key issue to be discussed in CRAN fronthaul architecture ;
- S3(RRU to RRU)is so complex and difficult to be controlled but can be converted to S2(illustrated in "Three-cornered hat" method).

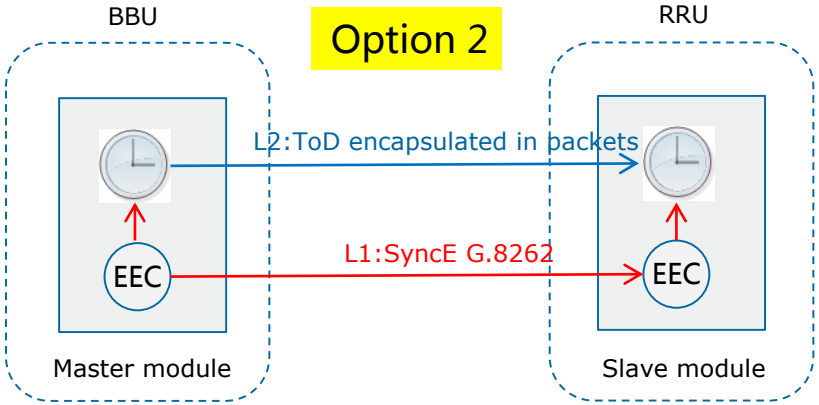


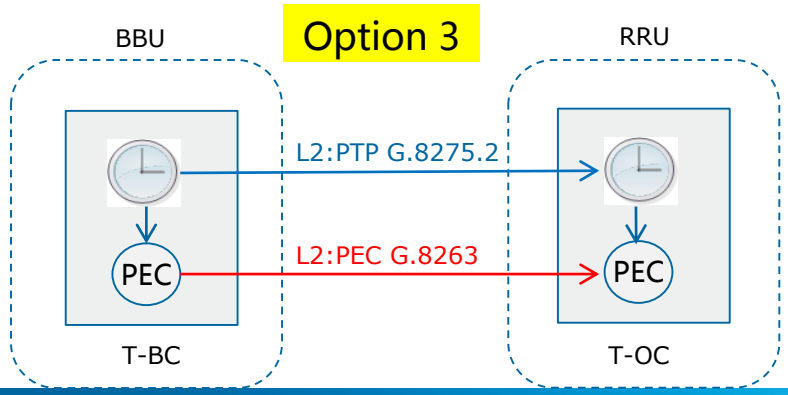
Candidate solutions

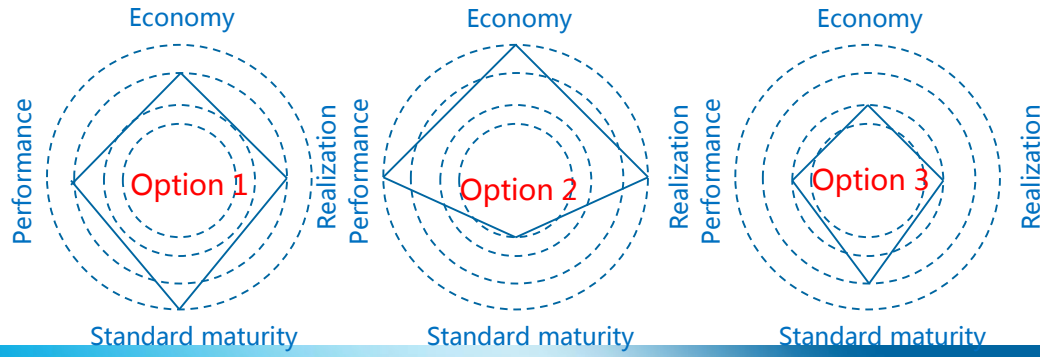
Candidate schemes are proposed towards time&frequency supporting on "S2" consideration as below

- Option 1: T-BC and T-OC are located in BBU and RRU respectively with G.826x and G.827x series standards supporting compatible with packet networks;
- Option2:Master and slave module are located in something called "remote PTP-head" technology, noted that ToD format and mechanism of link delay compensation should be specified in NGFI standard for further study;
- Option 3:EEC clocks are replaced by PEC clock in T-BC and T-OC, with the advantage of partial supporting for timing in PTP/syncE unaware networks(e.g through switch/router),however this option may be great challenge against PDV and complexity of algorithm for packet filtering, so it is recommended in low priority comparing to option 1 and option 2.







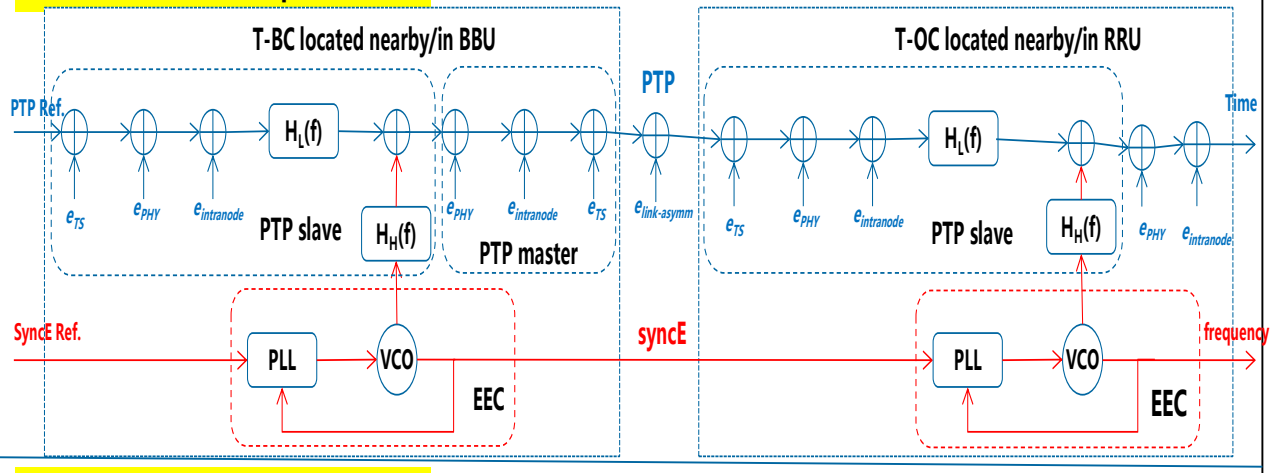


Models and Assumptions

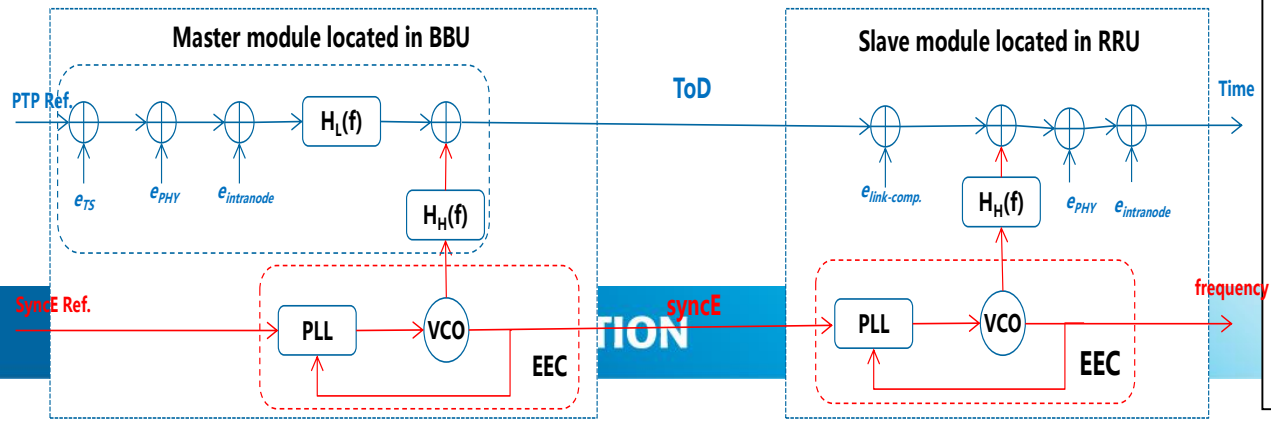
Two models are presented for option 1 and option 2

- some assumptions are made for further simulations based on G.8271.1 and G.8273.2 ;
- $e_{link\text{-}assym}$. due to dual-direction asymmetry of links between BBU and RRU in model 1 is proposed as key consideration;
- $e_{link\text{-}comp}$. due to single-direction compensation accuracy of link from BBU to RRU in model 2 is proposed as key consideration.

Model 1 for option 1



Model 2 for option 2



Assumptions:

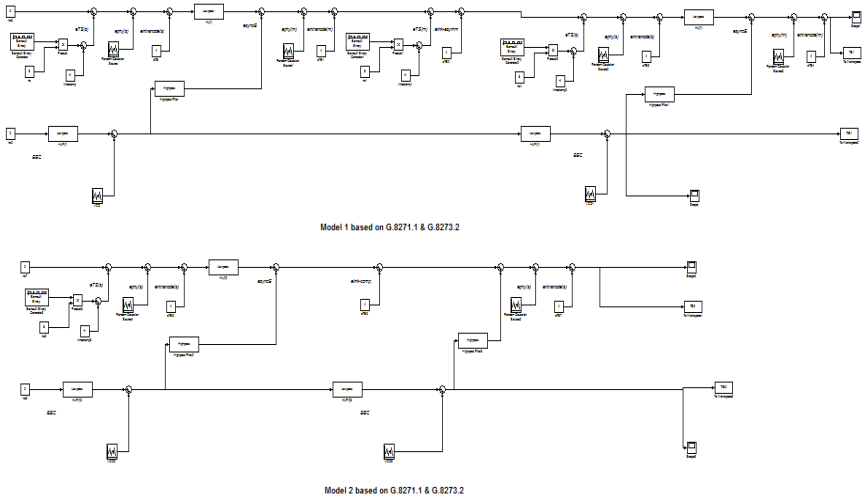
- e_{TS}:sampled errors of counter depending on clock rat e of PTP chip, compliance with Bernoulli distribution;
- e_{PHY}:effect of asymmetry and timestamp sampling uncertainty on the PHY, compliance with Gaussian distribution containing a static component and a time-varying component;
- $e_{intranode}$:effect due to intranode transmission as constant time error;
- $H_L(f)$:PTP to PTP noise transfer equivalent to a low-pass filter specified in clause 7.3.1 of G.8273.2;
- $H_H(f)$:SyncE to PTP noise transfer equivalent to a band-pass filter specified in clause 7.3.2 of G.8273.2;

Simulation results and Conclusions

Conclusions:

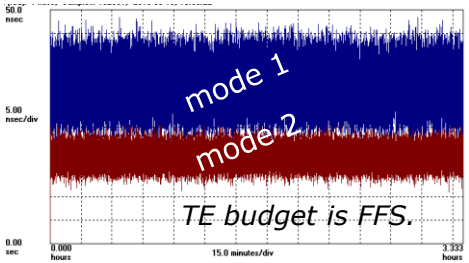
- As for Time synchronization aspects, model 2 is likely to show better performance than model 1 under the same simulation environment;
- As for frequency synchronization aspects, performance of model 1 and model 2 may be matching by EEC cascading;
- Specifications of synchronization performance is suggested for further study(FFS) by metrics such as accuracy,MTIE,TDEV,etc..

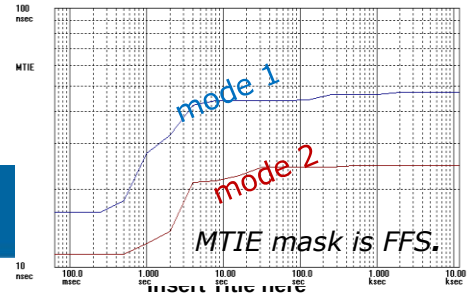
Building models via simulink toolbox of Matlab

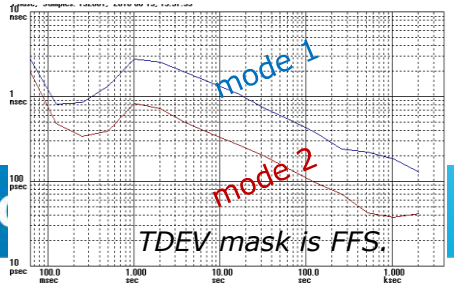


Simulation results of PTP within 12000s@16Hz

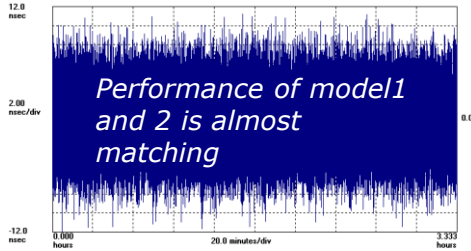
model	Accuracy(ns)	stability(ns)	
	max|TE|	constant TE	peak to peak dynamic TE
model 1	48.41	33.98	18.65
model 2	25.38	47.31	24.73

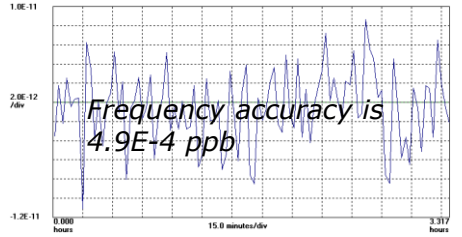


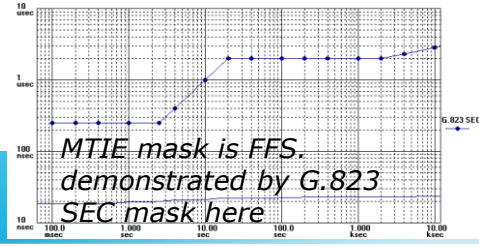


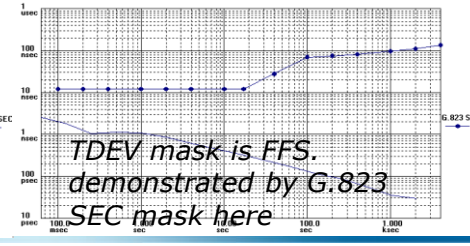


Simulation results of SyncE within 12000s@20Hz









Summary

Synchronization is focused for next generation CRAN fronthaul networks

- Considerations on synchronization are proposed according to different reference points;
- Errors between BBU and RRU called "S2" are key issues in CRAN fronthaul networks.

Three Candidate schemes are proposed

- In option 1 and 2,PTP can be adopted assisted with SyncE in PHY layer, whereas time and frequency can be delivered uniformly by PTP in option 3;
- Option 2 may be provided with better performance, however ToD format and mechanism of link delay compensation are required for further study;
- Option 3 is recommended in low priority due to great challenge against PDV.

Two functional models are presented for analyzing synchronization performance

- Frequency: stability such as MTIE and TDEV;
- Time: accuracy and stability such as max|TE|,MTIE and TDEV.

Other aspects of synchronization may be studied and discussed later on

- Performance such as holdover, transient response and so on;
- Sync. OAM and PTP profile.

Thanks!