Full Timing Support in a Telecom Network

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WSTS – 2021

Outline

- 5G Telecom Synchronization requirement
- Full Timing Support and Assisted Full Timing Support
- FTS and AFTS Deployment and Management
- Summary

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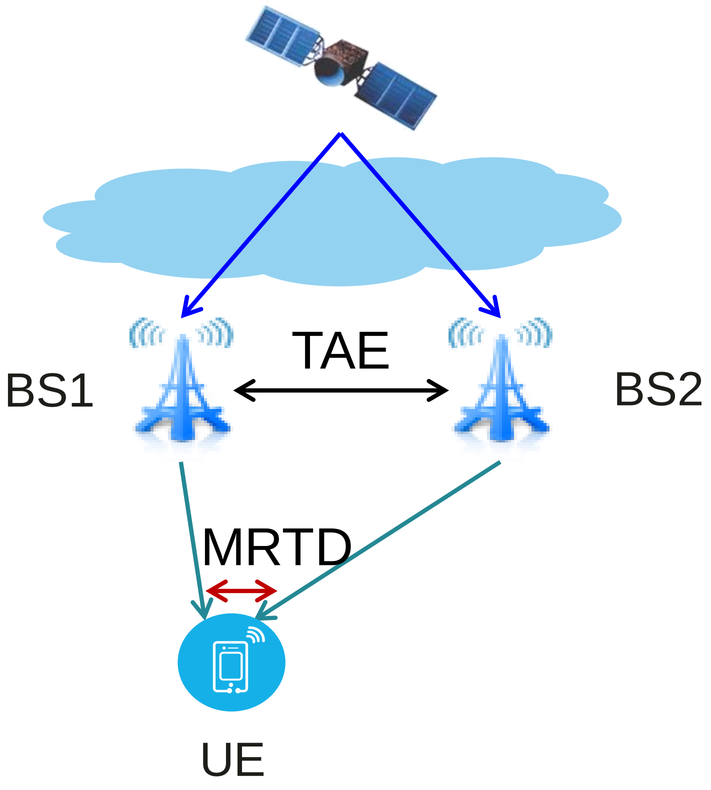
5G Telecom Synchronization requirement – 1

Requirements based on ITU-T G.8271 (03/2020) and 3GPP documents.



MRTD: Maximum Receive Timing Difference
TAE: Time Alignment Error
FR1 : 410Mhz – 7.125Ghz
FR2 : 24.25Ghz – 52.6Ghz

Application	MRTD at UE	TAE at BS
LTE-TDD (small cell) NR-TDD		3 us
Inter-band async FDD-FDD LTE DC Inter-band async EN-DC	NA	
LTE Sync DC Inter-band sync EN-DC	33us	3us
Intra-band sync EN-DC (co-located)	3us	3us
NR Inter-band CA	33us (FR1) 25us (FR1 – FR2) 8us (FR2)	3us
NR intra-band non-contiguous CA (FR1)		3us
LTE intra-band non-contiguous CA NR intra-band non-contiguous CA (FR2) NR intra-band contiguous CA (FR1)		260ns
LTE intra-band contiguous CA NR intra-band contiguous CA (FR2)		130ns
LTE MIMO (co-located antennas) NR MIMO (co-located antennas)		65ns

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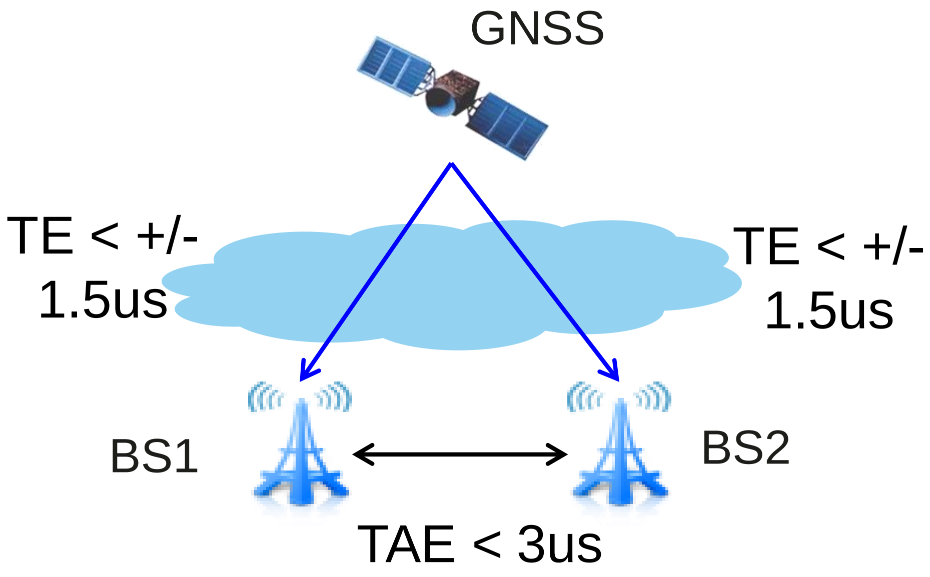
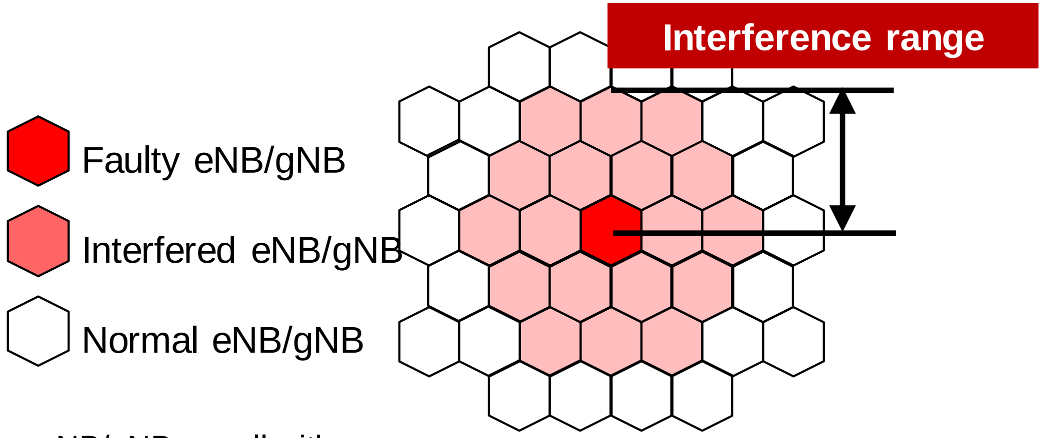
5G Telecom Synchronization requirement – 2

- The most important one is 3us phase/time sync requirement by LTE TDD and NR TDD.
- Generally, wireless base stations (BSs) gets time from GNSS, and a TE (Time Error) +/-1.5 us must be met for each BS.
  - Note, the GNSS could be co-located with BS, or remotely.



- If the timing of one BS does not meet +/- 1.5us, then this BS fails. It also interferes with its neighbor BSs.
- The interference range is dependent on the wireless spectrum, wireless signal power, etc.



Note: These eNB/gNB are all with same spectrum

5G Telecom Synchronization requirement – 3

- The consideration of reliability and robustness of phase/time synchronization are very important and necessary, in order to avoid BS timing to fail and to interfere with others.

- Several synchronization methods have been used in telecom application.
  - A local GNSS receiver at Base Stations;
  - PTPv2 (IEEE 1588v2) carries a remote time reference to Base Stations;
  - Physical layer clock (e.g., SyncE) maintains the time if the GNSS signal is lost.

- A combination of the above three methods may be a good choice for 5G telecom networks.

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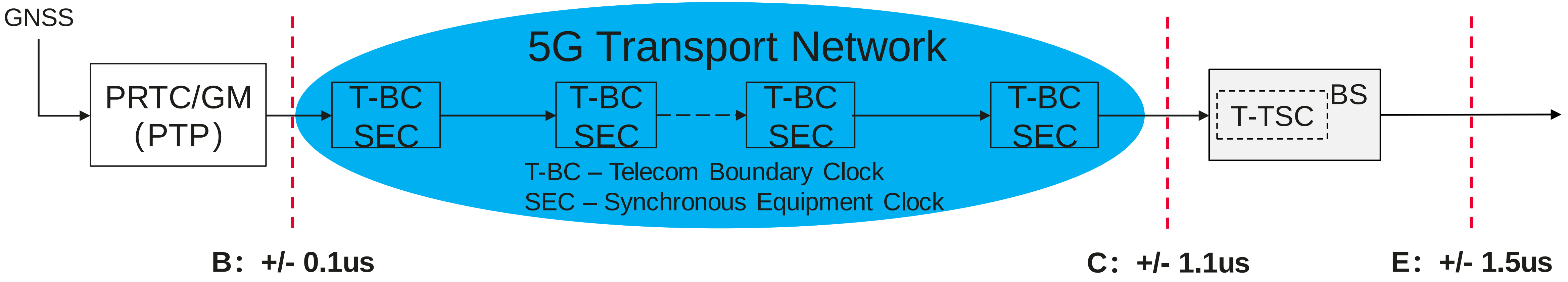
Introduction of Full Timing Support

- Full Timing Support (FTS) is one solution used for distributing PTP time via transport network to applications (Base Stations), defined by ITU-T Q13/15 (ITU-T Study Group 15 Question 13)
- It requires all of nodes in network to support PTP and physical layer clock function,
  - Under the normal operation, BS use its input PTP to get time synchronization;
  - When the PTP link is failed, the BS can use the physical layer clock to maintain the time.

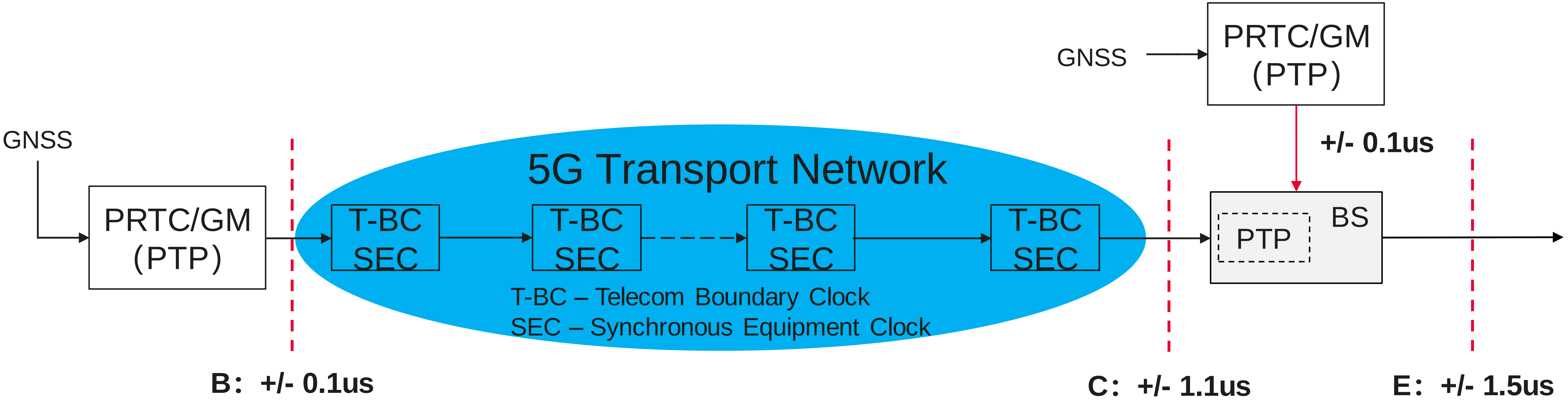


- Several ITU-T recommendations are defined for FTS solution.
  - **PTP profile**: ITU-T G.8275.1, guarantees the compatibility of devices from different vendors;
  - **Network limit**: ITU-T G.8271.1, specifies the number of hops, time accuracy of 5G transport network;
  - **Clock specs**: ITU-T G.8272 (PRTC/T-GM), ITU-T G.8272.1 (ePRTC/T-GM),

    ITU-T G.8273.2 (T-BC), ITU-T G.8262 (SEC), ITU-T G.8262.1 (eSEC).

Introduction of Assisted Full Timing Support – 1

- Assisted Full Timing Support (AFTS) solution is an enhancement of FTS solution, and it assumes the end application nodes (e.g., Base Station) with a local PRTC/GM reference.
- This is a combination of GNSS, PTP and physical layer clock.
  - Under the normal operation, generally BS use its local PRTC/GM as reference;
  - When the local PRTC/GM is failed (e.g, GNSS antenna is failed), BS will use its input PTP as a backup.
  - When the PTP link is failed, the BS can use the physical layer clock to maintain the time.



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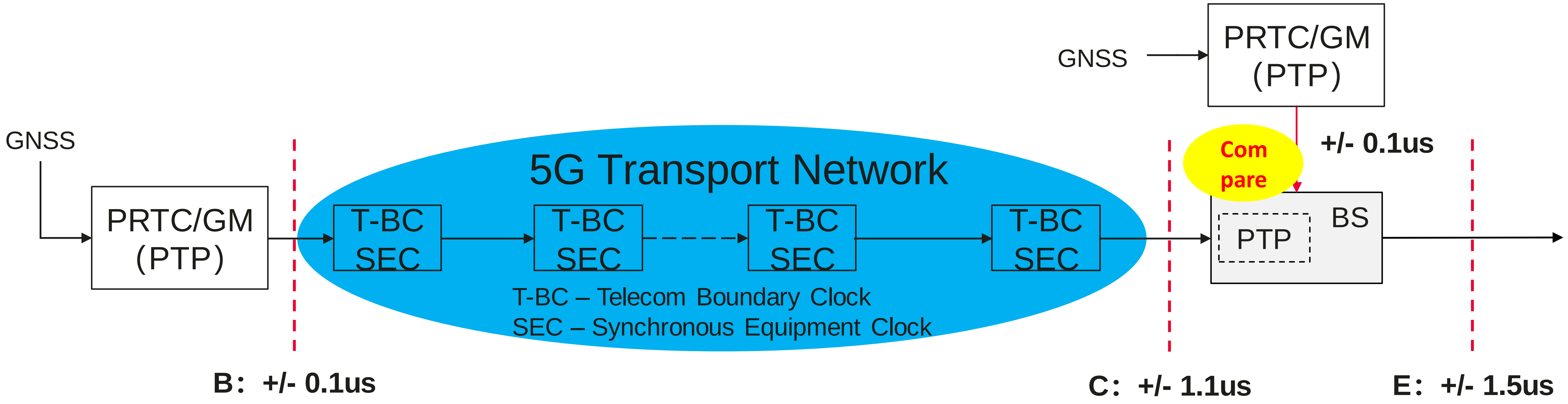
Assisted Full Timing Support – 2

- Another benefit of AFTS is, under the normal operation, the BS can compare the time error of its local PRTC/GM with the time error of PTP;
- BS can generate an alarm if the time difference exceeds a pre-set threshold;
- Then the network can be checked and fixed in advance, which is very useful from the perspective of maintenance.



FTS and AFTS Deployment and Management

- Due that the FTS and AFTS require all nodes to support PTP and physical layer clock, the setup and the validation of the network may be a difficult task, especially in a huge and complex network.

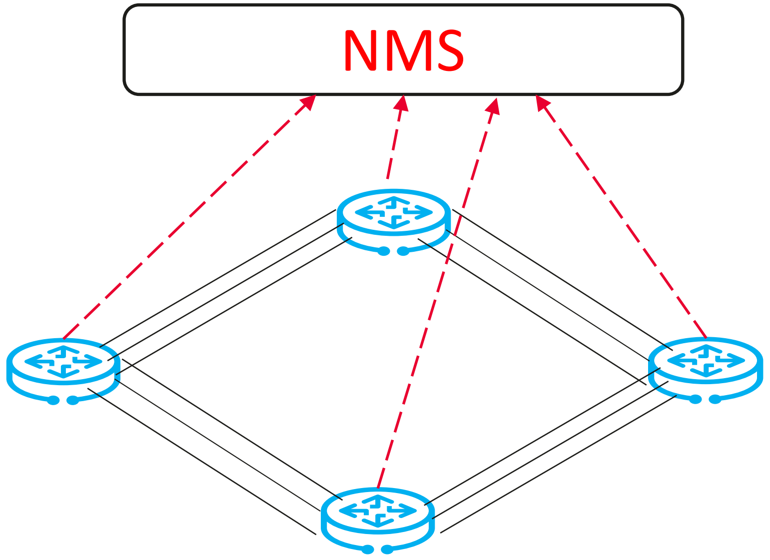
- When a Sync network is created, the configuration needs some professional skills, e.g., the knowledge of SSM algorithm, 1588 BMC algorithm.

- After a Sync network is configured, Sync topology needs to be confirmed, e.g.
  - Timing loops must be avoided;
  - Making sure that the synchronization flows from the core to the edge of the network.
  - The number of hops is within the requirement.

- An intelligent management tool may be expected, in order to decrease the configuration work, and reduce the professional skills requirement.

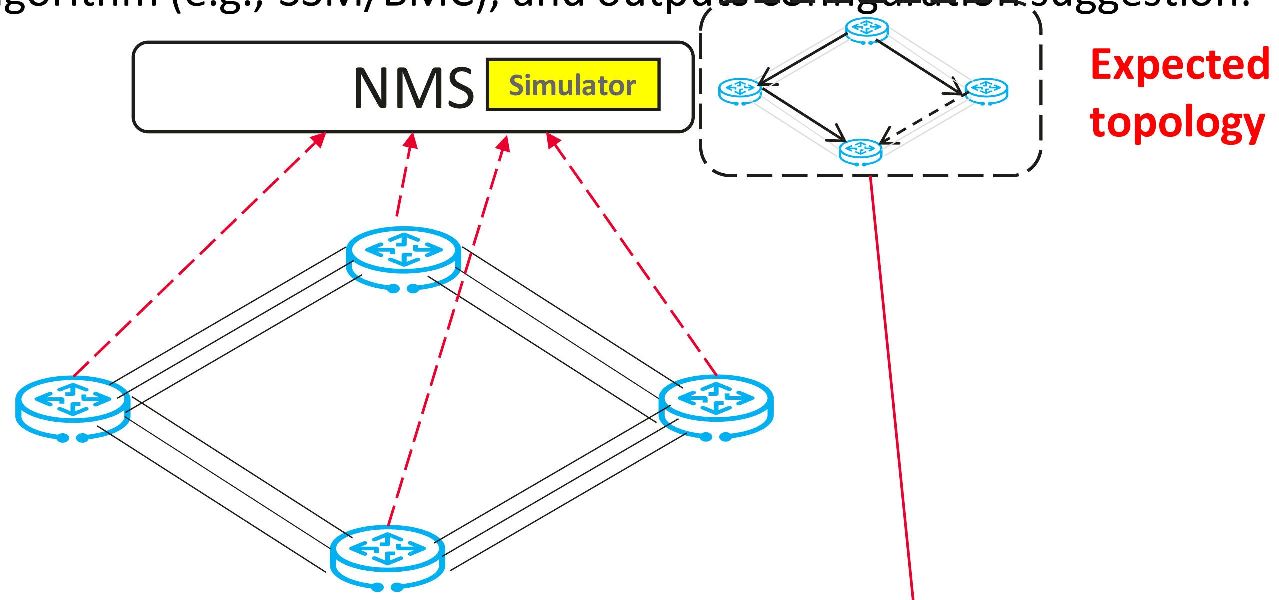
Example of intelligent management tool

❶: Collect Physical Topology

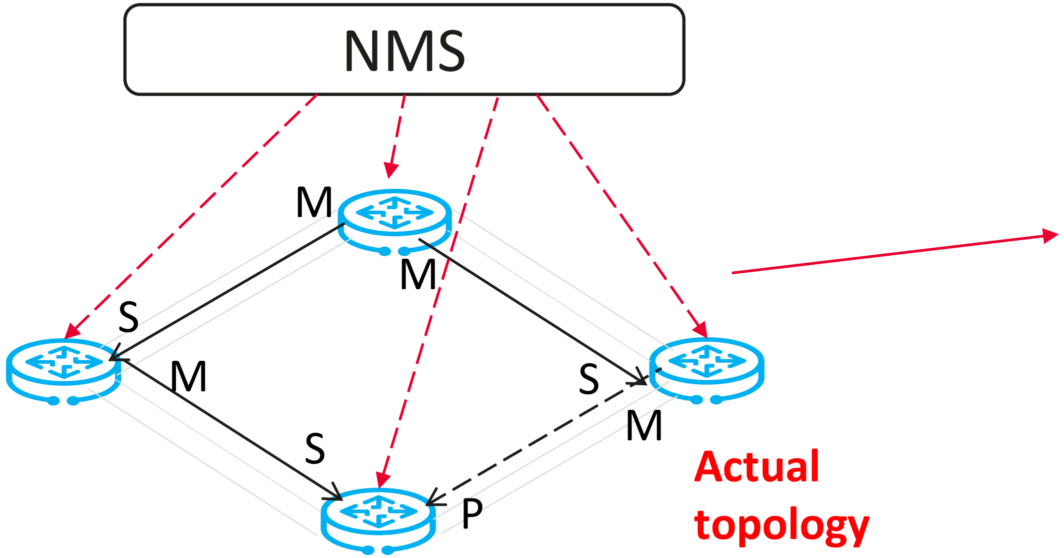


NMS - Network Management System

❷: Simulator calculates Sync topology based on source selection algorithm (e.g., SSM/BMC), and outputs configuration suggestion.



❸: Configure devices based on the configuration suggestion (e.g., priority, disable unused ports)



❹: Compare the actual topology and the expected topology

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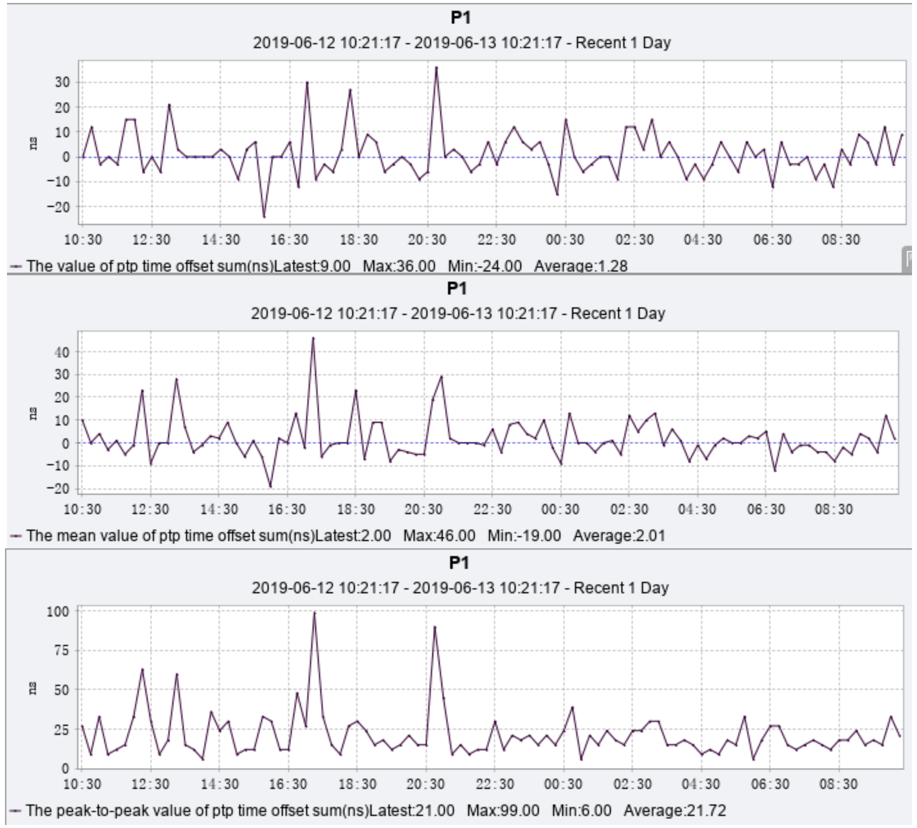
Time Performance Monitor at NMS

- Another useful function is to monitor time performance at NMS,
  - offsetFromMaster, accumulatedOffsetFromMaster, meanPathDelay, masterSlaveDelay, slaveMasterDelay
  - The device can report data of every parameter to NMS per a fixed period (e.g., 15mins)

offsetFromMaster (min, max and avg)



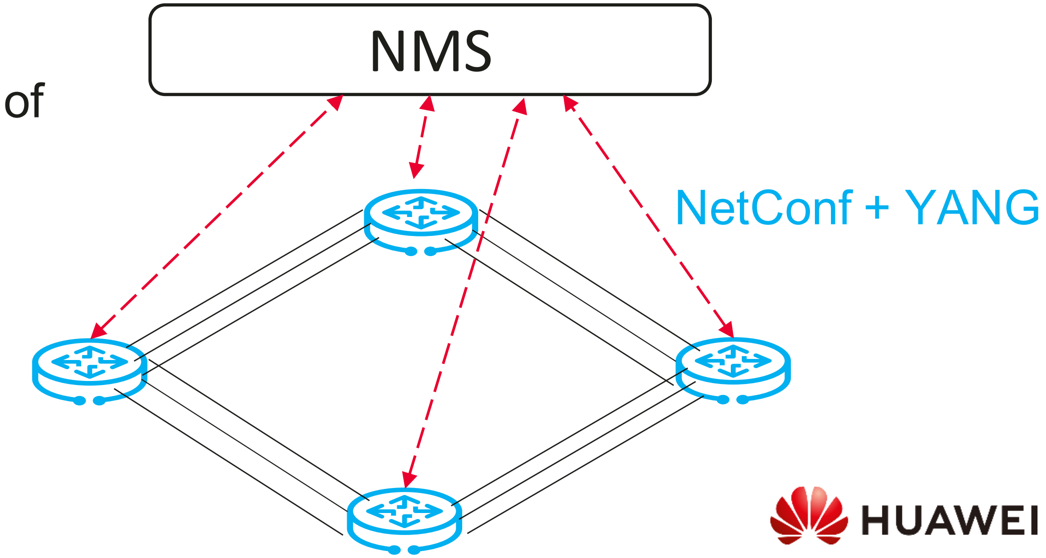
accumulatedOffsetFromMaster
(min, max and avg)

Sync Management Protocol

- In order to manage devices from different vendors by one common NMS, a further step is to define a standard management protocol, working between devices and NMS.

- NetConf (IETF RFC 6241) + YANG (IETF RFC 6020) could be used for Sync management

- Several SDO's are working on Sync YANG model
  - The YANG model of IEEE 1588v2 is IETF RFC 8575 (published at 2019);
  - The YANG model of IEEE 1588v2.1 is being discussed by IEEE 1588 group.
  - ITU-T SG15 Q13 and Q14 are working on YANG model of telecom PTP profiles (ITU-T G.8275.1/.2)



Summary

- Considering the importance of sync for 5G, reliability and robustness of Phase/Time Sync are necessary;
- A combination of PTP, SyncE and GNSS is a good choice, e.g., FTS or AFTS;
- An intelligent management tool may be useful, in order to decrease configuration workload or reduce professional skills requirement to set up and configure sync networks.
- A common network management protocol (e.g., NetConf + YANG) could be appropriate for Sync, and some standard works are on-going.

Thank you.

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