Results of PTPv2 based phase/time synchronization field trial in Orange Network: Results, Problems faced and Lessons learned

Presented at ITSF-2018 by

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work entirely accomplished by

Orange Labs in coordination with Orange France

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Reminder of the context

- 5G is becoming a reality in Asia, Americas, as well as in Europe

- Phase/time synchronization is mandatory for 5G-phase 1 (e.g. 3.5 GHz band in TDD mode)
  - But also for TDD-LTE (fix services) and for emerging LTE-A features (CoMP, inter-site CA …)

- 2 recommended solutions to distribute phase/time synchronization (for Orange networks)
  - where SyncE in addition to frequency delivery, is also used for backing-up phase/time

GPS "everywhere" i.e. on all cell sites (+ SyncE)	Centralized GPS + phase/time distribution with PTPv2 protocol + SyncE
• Readily available and the deployment could be faster when coupled with base station deployment	• Mostly available but require evolution of backhaul network (need anticipation)
• Not applicable for all cases (indoor, small cells)	• Applicable to most cases (macro and small cells, indoor)
• Risky (very vulnerable, no protection if no SyncE)	• More protection scheme (Time source redundancy)
• Cost effective for **small (limited geographical)** deployment	• Cost effective for **massive (nation-wide)** deployment

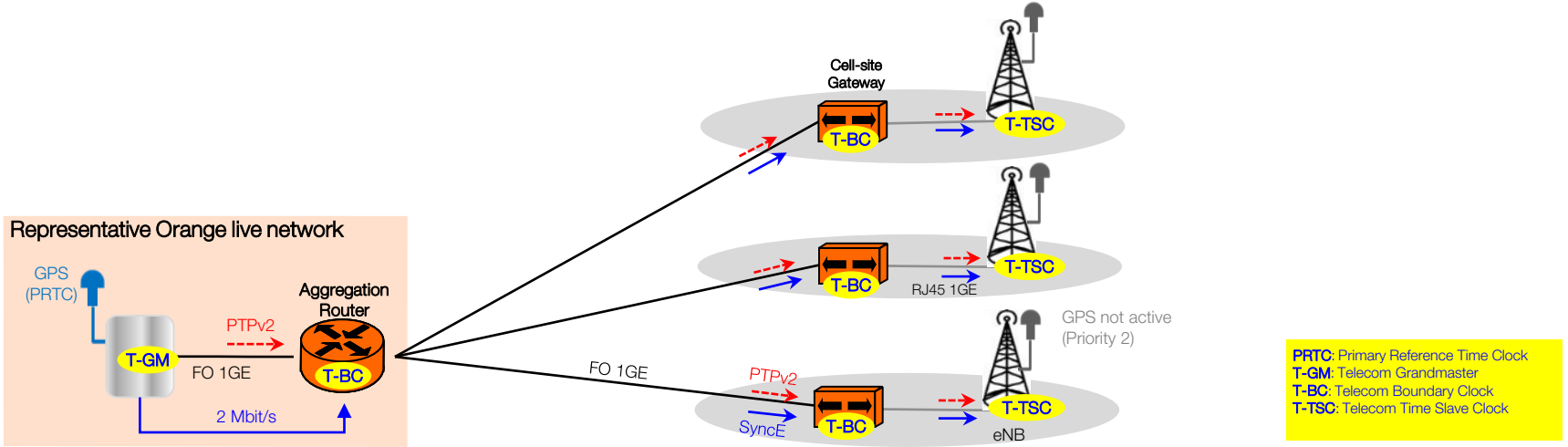
Objectives of the 4G trial

- **Interoperability:** To check the capability of Orange France (OF) backhaul network to be able to deliver accurate phase/time synchronization with PTPv2 solution
- **Performance:** To compare the radio KPI between GPS and PTPv2 synchronization (based on drive tests)
- **Experience:** To earn experience in phase/time measurement in the field
- **Evaluation:** To evaluate the effort to deploy PTPv2 in the entire OF mobile network
- **Reproduce:** To capitalize the experience for 5G deployment throughout Orange countries

Perimeter of the trial (1/2)

Initial set-ups:

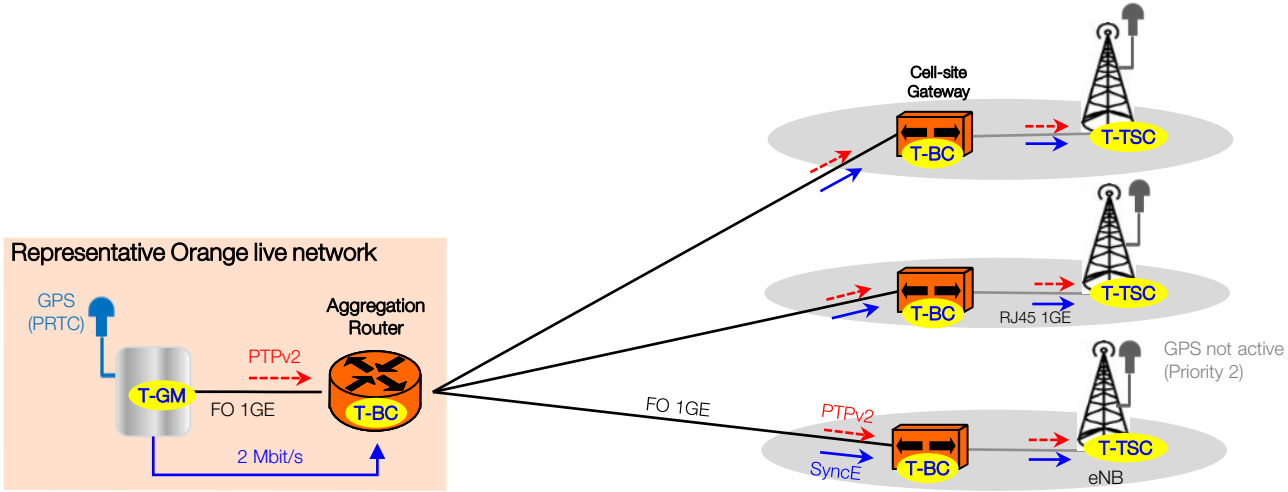
- eNBs were equipped with GPS receiver by default, but not activated for this test
- Mobile backhaul comprised of 1 Aggregation Router and 3 Cell-Site Gateway (CSG) Routers
- Aggregation Router, CSGs and eNBs were all from different vendors
- one trial was carried-out previously on the same geographical zone with GPS only



Perimeter of the trial (2/2)

Additional Hardware and Software upgrades:

- Backhaul network was transformed to support ITU-T Rec. G.8275.1 architecture
  - T-GM/PRTC: deployment of T-GM function + GPS antenna installation for PRTC function
  - Aggregation Router software was upgraded (to support standardized version of ITU-T Rec. G.8273.2)
  - CSG: existing HW was swapped with a new PTPv2 HW compatible release (to support ITU-T Rec. G.8273.2)
  - eNB: PTPv2 software license activation was required



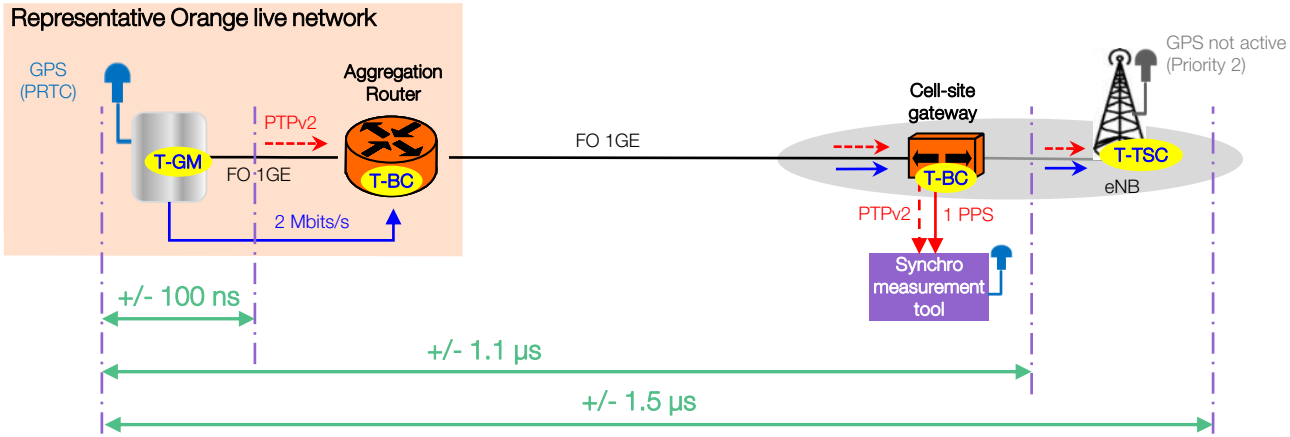
PRTC: Primary Reference Time Clock
T-GM: Telecom Grandmaster
T-BC: Telecom Boundary Clock
T-TSC: Telecom Time Slave Clock

Complications to deploy PTPv2 in live mobile network

- T-GM/PRTC
  - GPS antenna installation was tedious depending upon the geographical location and therefore relatively expensive
- Aggregation Router
  - software upgrade was needed; current deployed hardware has some limitations on PTPv2 capability (new HW will be deployed for 5G without limitation)
- Cell-site Gateway
  - new hardware and software upgrades were needed to be done to support the transport of PTPv2
- eNB
  - few vendors did not support SyncE backup by default (considering PTP-FTS solution was under evaluation)
- WDM (not used during trial)
  - few vendors has hardware limitations to interconnect to ingress/egress routers (in order to transport PTPv2)
  - new dedicated boards had to be deployed to support efficient PTPv2 transport (out-band method recommended)
- Edge Routers (not used during trial)
  - possible HW and SW upgrade to support and to be fully compliant with ITU-T Rec. G.8273.2 spec.

Accuracy required and evaluated

- 3GPP: required accuracy on the air interface is +/- 1.5 µs absolute (max |TE| for 4G / 5G-Phase 1 as of today)
- ITU-T: Time Error budget allocated to each equipment/segment of the backhaul



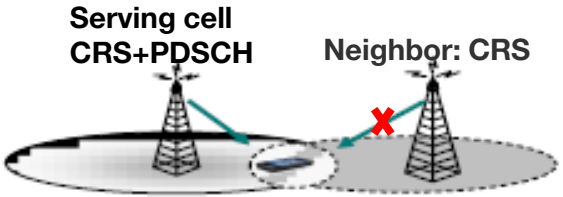
- Expected accuracy to be measured

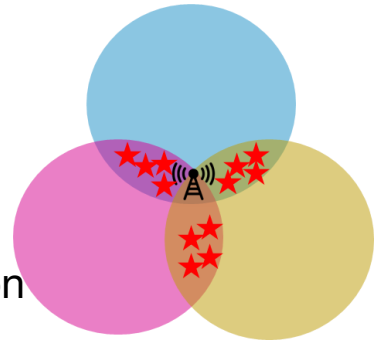
  → +/- 1.1 µs to be respected at the output of CSG

  → +/- 1.5 µs to be respected at the output of eNB

Evaluation of phase/time synchronization through drive tests

- Drive tests carried-out to evaluate the performance of radio under static and mobility conditions
- Network-Assisted CRS Interference Cancellation (NA CRS IC) is a feature (available since 3GPP release 11) allowing the UE to mitigate interferences due to Cell-specific Reference Signal (CRS) of neighbor base stations
- DL rate measurements
  - On cells of 1 site only
  - 2 types:
    - Drive around the site (4-5km)
    - 3 static points
  - Limited to area where there are high interferences ★
  - Comparison between GPS and PTPv2 synchronization
- Even if limited, tests allow to compare both synchronization solution





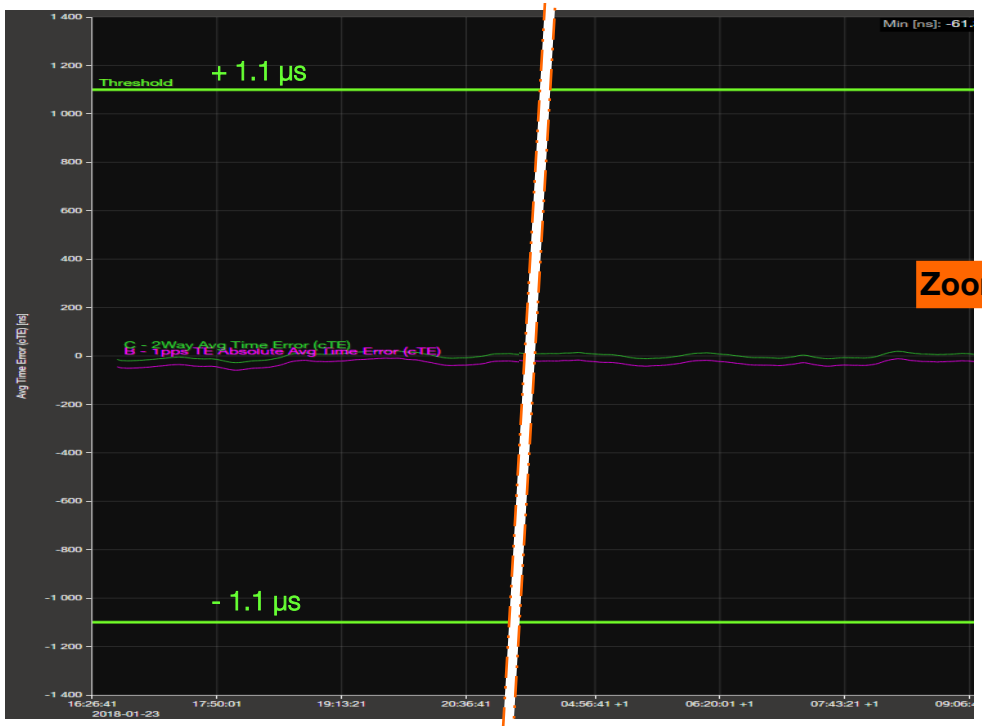
Outcomes of the tests and lessons learned

- Results of PTPv2 transport and distribution
  - No interoperability issues ☺
  - Very good performances of the PTPv2 transport in the field (< +/- 60 ns) ☺
  - Accuracy similar (better!) to a GNSS receiver (< +/- 100 ns) ☺
  - Efficient Time Holdover thanks to SyncE assistance at the aggregation and CSG ☺

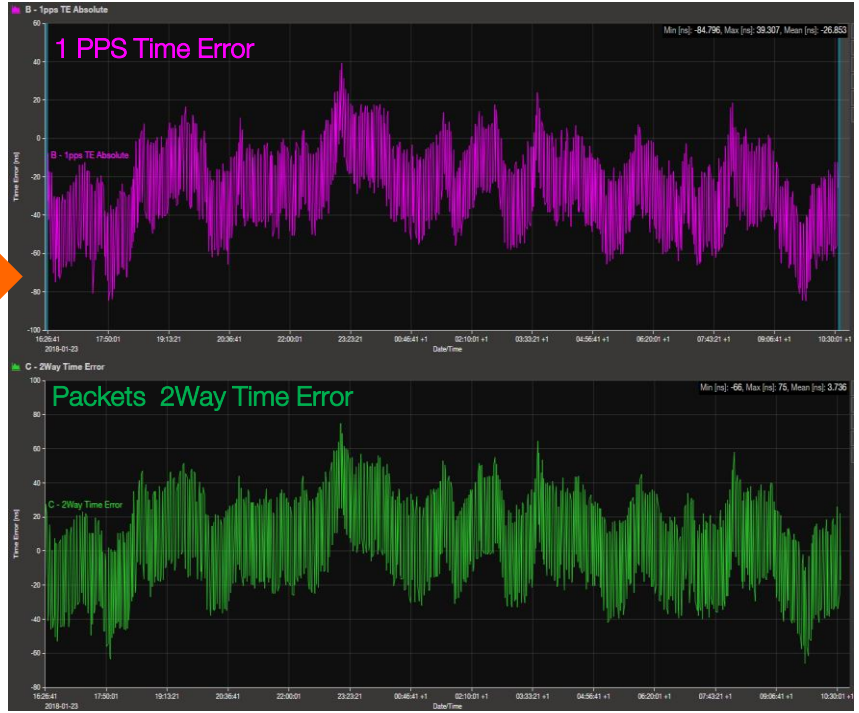
- Results of Drive tests
  - Same radio KPI with drive tests
  - Note: minimal configuration (1 site with intra-site cells only)
  - No difference on measured gain between GPS or PTPv2 ☺
    - 10-20% of gain on overlap areas (same value as during GPS trial)
  - Inter-site configuration missing to complete analysis

Synchronization measurement in nominal mode

- Example of one measurement for 20h



Zoom



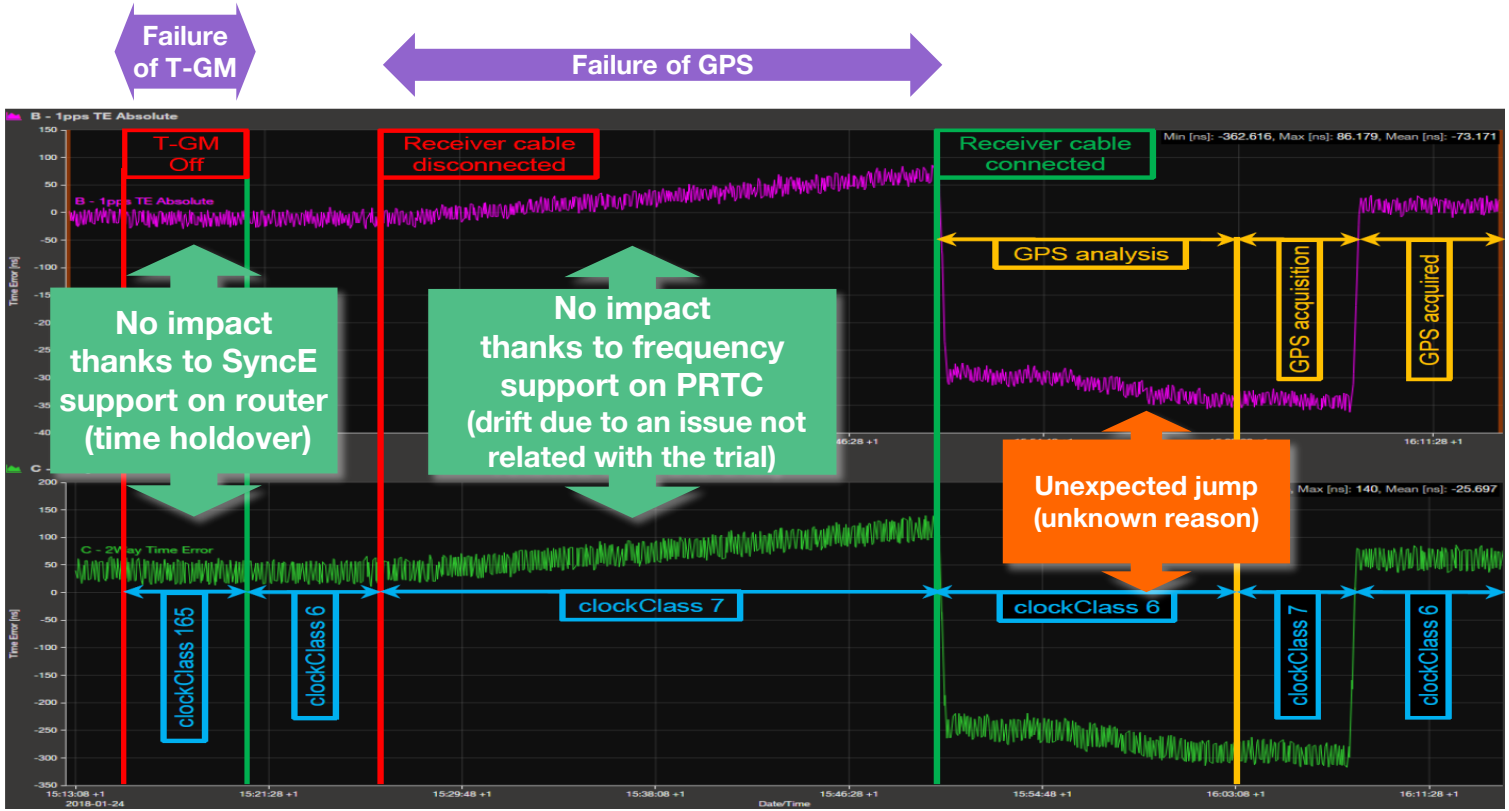
- Very good accuracy

Mean value (over 5 measures) = -5 ns (peak/peak noise ~40-50 ns)

Mean value (over 5 measures) = 22 ns (peak/peak noise ~40-50 ns)

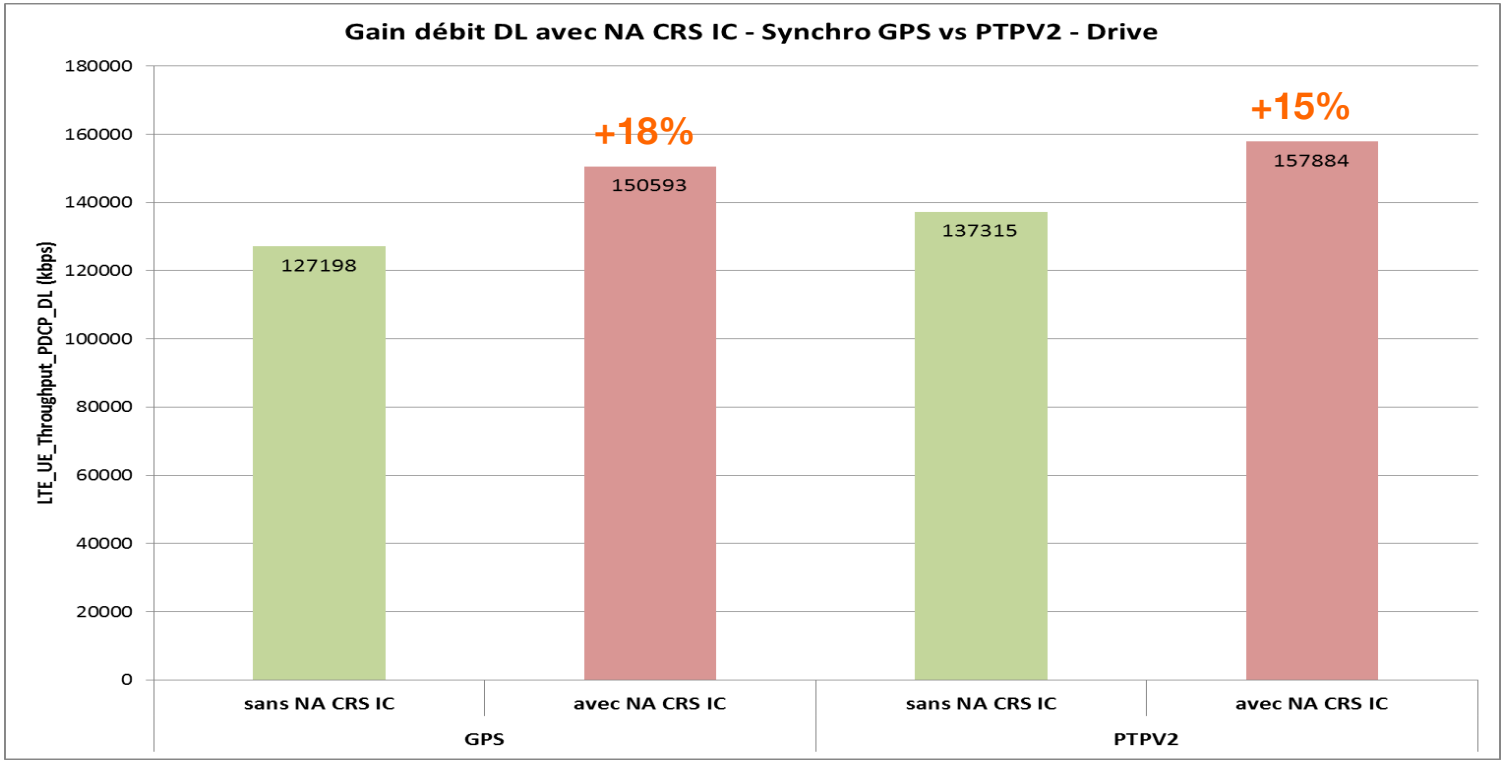
Constant time offset between 1 PPS and PTPv2 = 30 ns (mainly due to CSG implementation)

Degraded mode: 2 failures simulated



- Time accuracy maintained thanks to frequency layer assistance (OLN recommendation)

Results of drive tests



Similar (better!) gain with NA CRS IC feature with GPS or PTPv2 synchronization

Lessons learned

- **Measurement of PTPv2 accuracy on the field is not very easy at all ☹**
  - Measurement equipment is not so easy to be carried around in the field ☹
  - Time consuming when looking for a time reference (GPS) inside the buildings ☹
  - Measurement tools have different behavior (implementation, calibration, delay compensation…) at different geographies ☹
  - Coordination between the RAN team and the Transport team may not always be so easy while trouble shooting eNB synchronization issues (‘who-does-what?!’ situation) ☹
  - End-application (eNB) limitations (e.g. no measurement point, no SyncE support, etc) ☹

Conclusion and next steps

- Recommended solution based on PRTC (centralized GPS) + PTPv2
  - is fully efficient in live network when considering nation-wide deployment
  - has same accuracy as GPS deployed on cell site (even better depending upon topology)
  - could offer more robustness with PRTC/Grandmaster (time source) redundancy

- The use of SyncE
  - is shown to enhance PTPv2 performance and ensures backup of GPS or PTPv2 perfectly

- Work is on-going with Orange France and other Orange countries to prepare the network for 5G

- Sync in the context of 5G deployment is inevitable and deployment of Sync solutions and Sync measurement mthods should be anticipated well in advance

Thank you