The Challenges of phase sync Deployment

Zagreb, October 2020.
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Where we stand today in synchronisation

- Synchronisation takes up more and more of my work
- Requirements for different type of services
- Synchronisation is a slow process, yet managers require quick results ☺
- Frequency synchronisation well established
  - Use of SyncE in MPLS core
  - HQ Sync POP provides frequency for all network
  - Leased PRC source from incumbent
  - ePRC available
- Obvious trend to expand to phase sync
  - Some modest implementations as „islands”
    - IEEE1588 use for cable
    - G8275.1 for Inter eNb carrier aggregation

A1 Croatia 5G blueprint- stuck for obvious reasons

- In 2020 Croatian regulatory agency nominated the city of Osijek as a first 5g city in Croatia
  - Osijek being the 4th biggest city with a staggering 108.000 inhabitants from 2011
  - Civil protests to stop 5g rollout sporadic
    - One island to forbid 5g installation
  - First sites more as a testing facility to observe performance
    - Scarce selection of mobile phones doesn’t push the rollout
- Several IT based companies showed interest for 5G service
  - Mostly gaming based
- To mitigate 5G NR (stand alone) rollout, look for an alternative solution
  - Dynamic Spectrum Sharing (DSS) as a effective enabler
  - Much faster deployment
    - Share LTE spectrum in FDD band with 5G
    - Requirements for phase less stringent

Phase accuracy requirements

MOBILE SEVICES

5G FDD

- ± 500us accuracy at RBS air interface for FDD networks

5G NR TDD

- ±1.5us time budget from the PRTC to the antenna reference point (G8271.1 network limits)
- ±1.1us from PRTC to PTP end node (Baseband Unit)
- 3us time alignment between antenna reference points

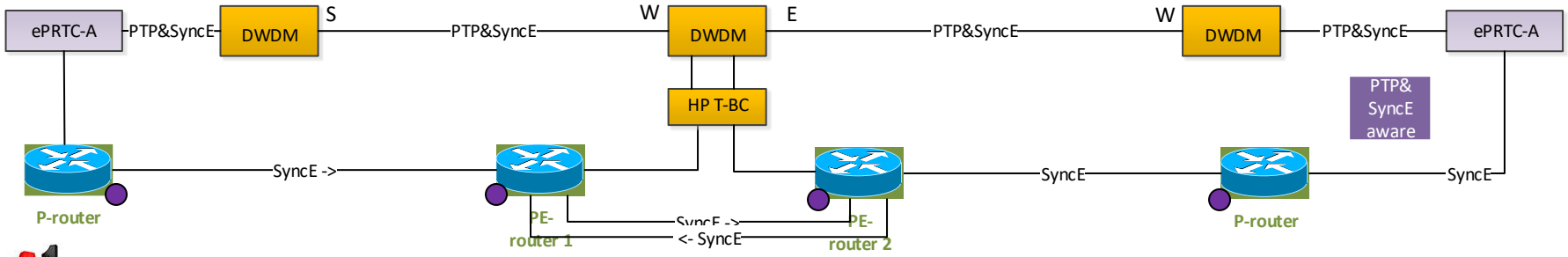
FIXED SERVICES

Cable TV

- IEEE1588 island providing phase sync to remote phy
  - Cable modem terminations system (CMTS) when used with remote phy nodes (RPD) splits functions of Modular Headend Architecture (MHA)
- ± 500us accuracy at RPD and CBR

5g NR TDD challenges

- How to ensure good stability and performance of 5g NR during possible outages of the network?
- What challenges do we have and how to approach them?
  - Ensure SyncE and G8275.1 profile to be delivered and maintained to each 5g NR base station
  - Running syncE is pretty straightforward, in combination with PTP requires some precautions
  - Our approach is to have T-BC node presence in every county center
    - Having ePRTC performance is a must at the main center
    - PTP and SyncE are transported from the main HQ to county center
    - Use of specific cards at each DWDM node with use o OSC channel to eliminate asymmetry
    - Observe the flow of PTP and SyncE at the diagram (violet circles represent PTP aware nodes)



5g NR TDD solutions – lab testing

- Recently performance test of 5g base station started
  - Test showed in lab that holdover time for 5g NR baseband is 2hr and 10 minutes without PTP (see the table on the right)
  - This leads to overall expectation that this applies to most of the future 5g nodes
  - This time is not enough to replace T-BC when it fails in county center
  - How to extend the holdover of the node?
    - Vendor approached us recently and offered new feature called
      - Assisted Time Holdover for PTP/Eth
      - SyncE source must have PRTC or ePRTC quality (at least QL-TLV required)
      - Currently no support for it
      - Feature amended to support PRC values

	Description	**Event time start**	**Event time End**	**Comment**
1	observe the performance of the 5G base station if the link that carries PTP only traffic towards 5G BB is down			This is the case when there is no PTP present but traffic is still operational
1a	Action: shut the interface Te0/0/0/17 to disable PTP towards 5G baseband	10:24:34		5G BB in time holdover ethernet port down
1b	Observe if there are any events		12:34:55	Sync Time and Phase Accuracy Too Low Service Unavailable (Cell Down)

5g NR TDD solutions – assisted time holdover

- Assisted Time Holdover for PTP/Eth trial
  - Expectations to extend the holdover to a time necessary to replace T-BC if one fails
  - Trials will show if the extended time in holdover is sufficient to serve the purpose
- First results in the lab environment showed that with PRC quality without PTP, cells are still up after several days
- Next step is to evaluate performance in real network scenario
- Promising feature for the quality performance after a T-BC failure happens

```
9788                                    Transport=1,Synchronization=1,Radio
EquipmentClock=1
================================================================================
========================================
bfnOffset                               0
clockOperQuality                        1 (PRC)
clockSettledQuality                     1 (PRC)
currentAssistingReference               Synchronization=1,RadioEquipmentClo
ck=1,AssistingReference=1
currentRadioClockReference
freqDeviationThreshold                  5000
minQualityLevel                         Struct{3}
>>> 1.qualityLevelValueOptionI = 2 (SSU_A)
>>> 2.qualityLevelValueOptionII = 2 (STU)
>>> 3.qualityLevelValueOptionIII = 1 (UNK)
nodeGroupRole                           0
(NOT_ACTIVATED_AS_NODE_GROUP_MEMBER)
radioClockPriorityTable                 [1] =
 >>> radioClockPriorityTable =
Transport=1,Synchronization=1,RadioEquipmentClock=1,RadioEquipmentClockR
eference=PTP
radioClockState                         6 (RNT_TIME_LOCKED)
radioEquipmentClockId                   1
selectionProcessMode                    1 (QL_ENABLED)
timeHoldoverAlarmConfig                 Struct{2}
>>> 1.enable = false
>>> 2.filterTime = 3
timeSyncAssistanceState                 3 (ASSISTANCE_ACTIVE)
```

5g FDD solutions (DSS) – challenges

- Objective is to quantify performance metric in case of DSS wide network deployment
- Small percentage of the PTP aware transport network making the analysis more complex
- Required accuracy of 500us seemed quite easy to conform
  - Analysis showed that network asymmetry could be assisting factor to time error performance in a great deal
    - Well known fact that for every 2us of asymmetry equals 1us of time error
  - Quality of service is second important factor (DSCP bit 46, Exp5 bits to be unique)
- How many reference masters are allowed at 4g/5g baseband?
- How to define the number and location of the master IP's to sustain the worst scenario?
- What kind of performance is expected in some remote location

5g FDD solutions (DSS) – trials and results

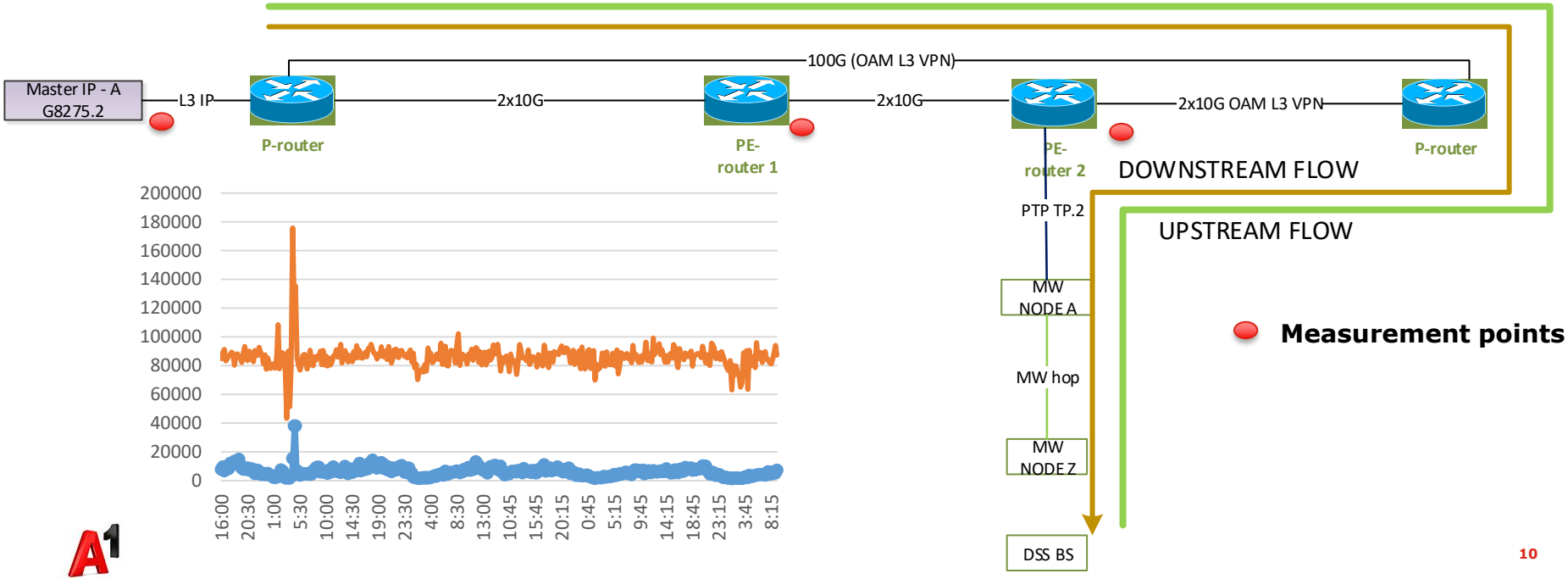
- One DSS base station selected for performance evaluation
  - Distance from the master relatively long (circa 450 km)
  - One MW hop included
  - Forward and reverse path more or less similar (asymmetry not influential part)
  - The offset from the master values obtained from the baseband counters interesting ((see the formula below)
    - Average values from both master IP's show similar values
    - Max values were quite different from the average
    - 15 minute observation interval
    - Two master IP addresses

- SLAVE_GM1 ptpOffsetFromMasterAvg 6572
- SLAVE_GM1 ptpOffsetFromMasterMax 86664
- SLAVE_GM2 ptpOffsetFromMasterAvg 5329
- SLAVE_GM2 ptpOffsetFromMasterMax 85722

Mean path delay = (forward path delay + reverse path delay) / 2
Offset from master = Mean path delay - Forward path delay

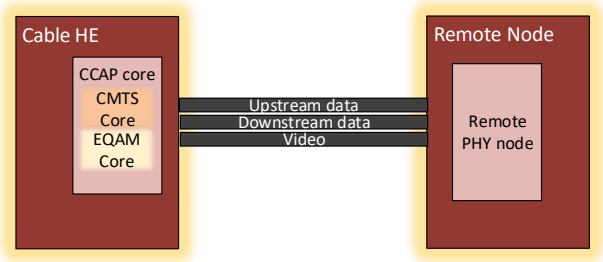
5g FDD solutions (DSS) – traffic flow

- Below is the traffic flow in the downstream and upstream for the selected BB
- It’s possible to collect 15 minute average and maximum values of the master offset



Cable TV – G8275.2 challenges

- Requirement is to provide PTP to a cBR and remote phy devices (RPD)
- Current solution for the network segment that connects CBR and RPD's is routed L3 VPN
- Looking from the profile 2 standpoint of view, it's sufficient to connect PE router (being T-BC for this profile (interop functionality)) to aggregation device that sits in front of cBR
- During testing we discovered that master IP on the router can not be configured as a virtual or logical interface (a loopback interface)
  - Only physical interfaces can be used
- The values from the real network showed much better performance than DSS solution (values in ns)
  - Distance from the master to slave around 550 km without asymmetry
  - Master offset : **-4853**
  - Path delay : 4060873
  - Forward delay : 4056020
  - Reverse delay : 4055717



Conclusion

- ePRTC A or B
  - Frequency stability of 10-14
  - Having the holdover period of 14 days exceeded
- East-West T-BC redundancy key enabler of the best possible performance against one or even two failures
  - GNSS as a backup at a remote T-BC location
- Having the stable PTP and SyncE network is a pillar for quality performance
- Use interop functionality where it will be available to bring profile 1 closer to CMTS


Hvala!
Thank You!
Q!?