Sync Evolution in the A1 Croatia

Bucharest, listopad 2018.
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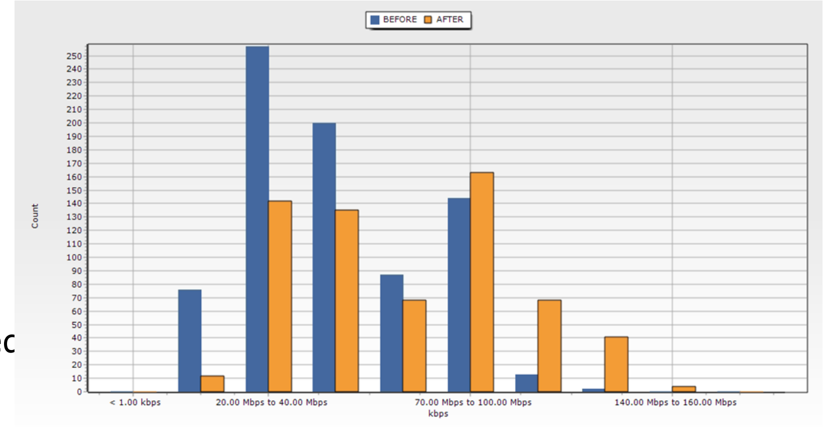
Standing here today after a year
Inter eNb carrier aggregation trial

- A trial with 15 mobile stations
  - Profile G.8275.1
  - Succesfully tested and deployed and worked during advent time in Zagreb
- Trial ran into some technical issues on the RAN side
  - GPS outage caused eNb to freeze and shut down all 3 technologies
  - Remedy taken and problem solved by adjusting the parameters
  - Manual block of PTP disables cell
- And also on transport side
  - Only 7 PTP clients per Cisco router
  - „Synchronisation is a myth, mobile base stations can run without sync" (my manager, guru of many things ☐)

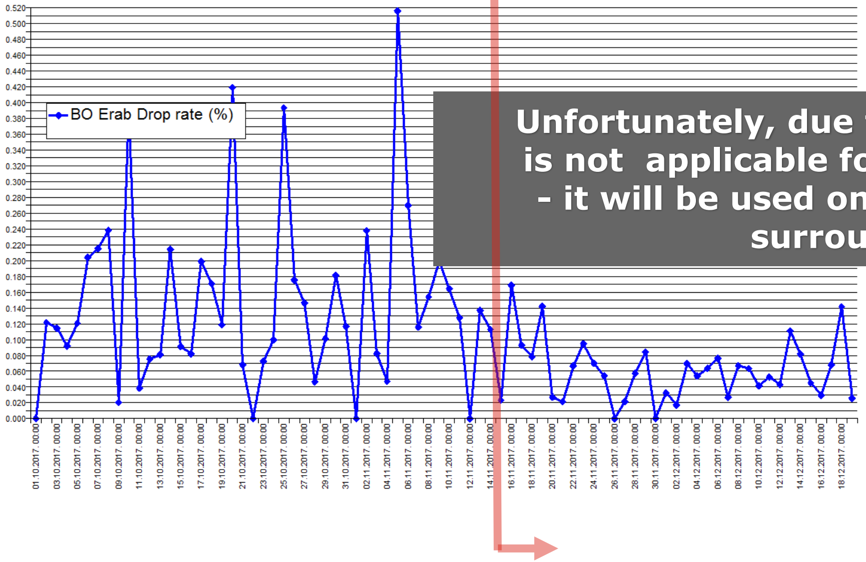
Standing here today after a year
Inter eNb carrier aggregation trial

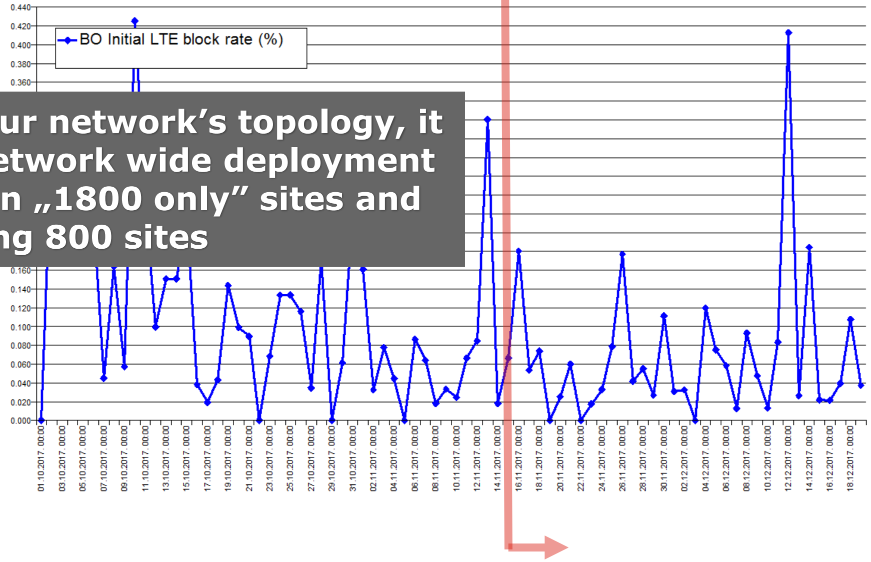
- Average throughput:
  - Before -> 69 Mbps
  - After -> 111 Mbps
  - Gain -> 61%
- one way X2 latency less then 0.4 ms
- Fraction of peak throughput: 64%
- Feature improved downlink throughput in targetec area without any drawback



Standing here today after a year

Inter eNb carrier aggregation trial

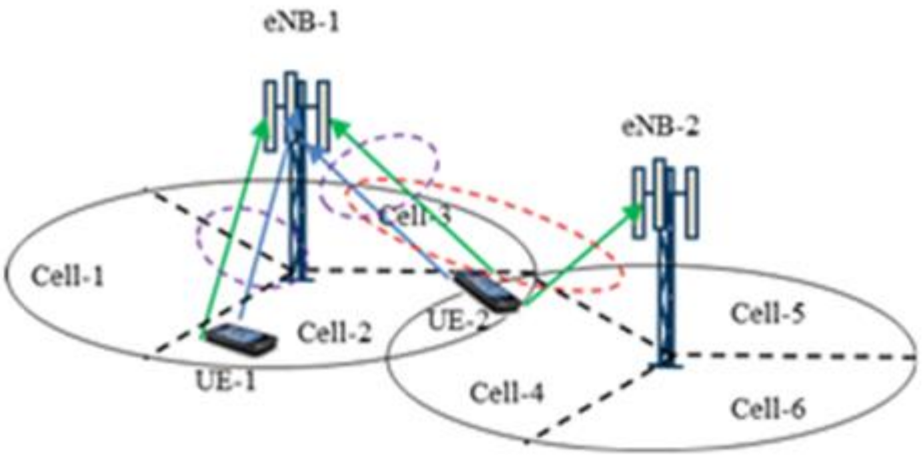




Unfortunately, due to our network's topology, it is not applicable for network wide deployment - it will be used only on „1800 only" sites and surrounding 800 sites

Current trends and drivers
Elastic RAN with Uplink CoMP

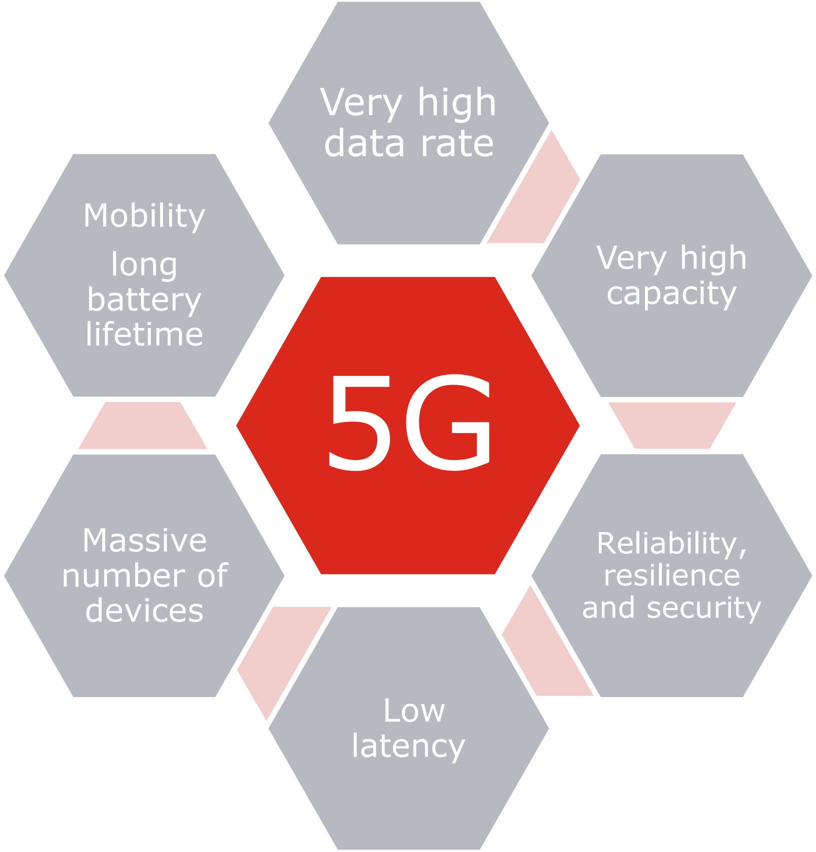
- Lte advanced features left with few special cases
  - Inter eNb carrier aggregation as proven but low scale application
  - Elastic RAN UL comp as a promising feature
    - Again limited scope and footprint
- Elastic RAN Uplink Coordinated Multi-Point Reception
  - Uplink CoMP improves uplink bitrate by combining antenna signals from multiple sectors belonging to different cells
  - The benefit is largest in the border area between sectors
  - For users with poor uplink channel quality
- New interface E5
  - 10G interfaces



Pic. UE’s on the cell border behaviour

Current trends and drivers
5G evolution

- 5G evolution
  - Non-standalone(NSA)NR
    - ASN.1 freeze in March 2018
  - Standalone(SA)NR
    - ASN.1 freeze in September 2018
- Band utilization
  - 3,5 GHz NR n77, n78
  - Possibly 100MHz channel bandwith available
  - OFDM based, but more efficient per MHz than LTE
- User experience
  - 1.6 Gbps DL possible via NR
    - 100MHz spectrum 4x4 MIMO, 3:1
  - 1 Gbps DL via LTE in theory
  - Mid-band TDD terminals available 2019



A1 Croatia 5G blueprint

RAN	• Spectrum strategy for optimum freq utilization • New antenna design supporting existing tech/freq + mMIMO • Site design for 5G including power supply dimensioning and mast strengthening • 5G small cell design • NB-IoT • Massive MIMO • Introduction of TDD
Packet Core	• vEPC design (regional packet core nodes design) • CN NW slicing • NextGen Core
Transport	• Transport network design to support > 10 Gbps of air capacity • Time &Phase Synch for TDD • Fiber network development according 5G plan
5G services, and IT infra	• IT network, cloud and storage design and dimensioning • Mobile edge computing
OSS and tools	• OSS and supporting tools • Measurement equipment • RAN planning tool • GIS visualization

Performance requirements for phase

- Note that all values are in nanoseconds
- Class A and B derived from G.8273.2 standard

	Parameter		T-BC, T-TSC				
			Already specified		Proposed new values		
			Class A	Class B	Class C	Class D	Class D+
PERFORMANCE REQUIREMENTS	max|TE|	Unfiltered	100	70	20-22	10	
	$cTE+dTE_L$				15	8 (9?)	5
	cTE		50	20	8	5 (7?)	4
	dTEL (MTIE)	constant temp. Up to 1.000 sec	40	40	10	5 (3?)	2
		var. temp. up to 10.000 sec	40	40	FFS	5 (to be confirmed)	
	dTEL (TDEV)	constant temp. Up to 1.000 sec	4	4	2	1	
	dTE_H	Up to 1.000 sec	70	70	20	10	

Evolution of classes

- Class A on all phase supported transport equipment from the last 3-4yrs
- Newest transport equipment on the market bring in the class B or below available since this fall
  - In the future probably transport equipment will move closer to higher classes thus ensuring better end to end performance
  - Density of 10G SFP+ ports increases a lot
- MW equipment currently supports only class A but in near future new cards will support also class B
- Small islands could use GNSS source to feed surrounding slaves with PTP and SyncE

SYNC core requirements and challenges

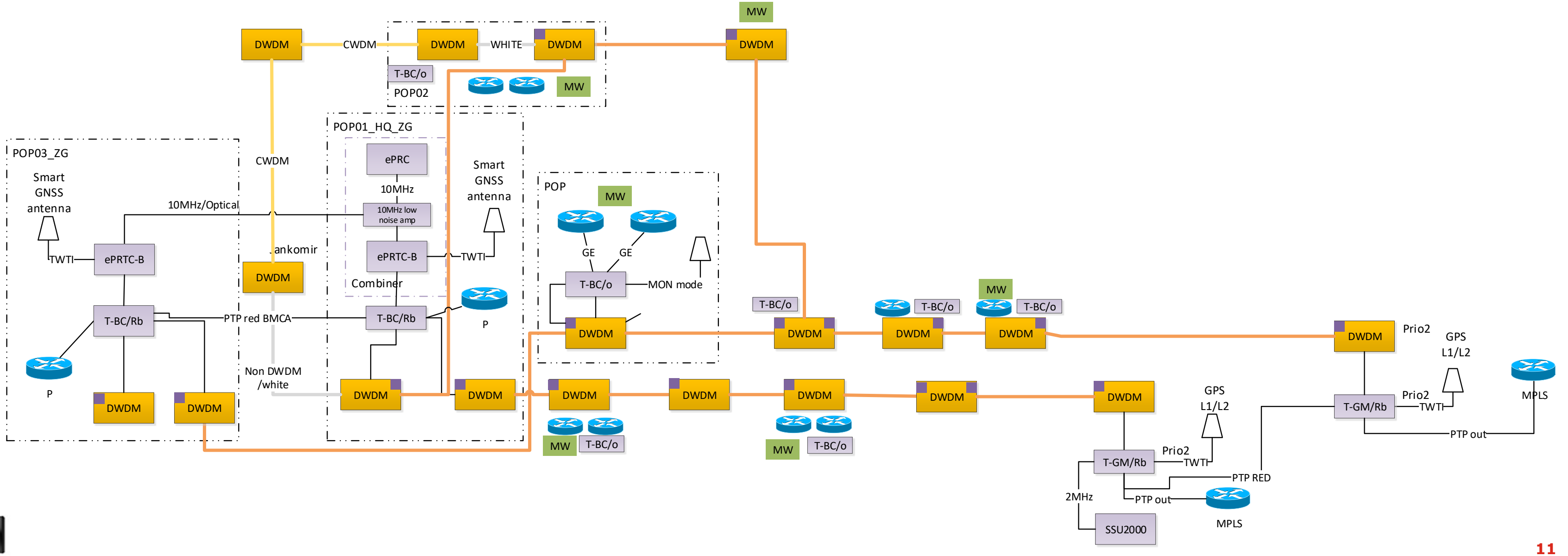
- The question is what is the requirement in core sync?
- How to ensure good stability and performance during possible outages of GPS?

- Requirements getting tougher and tougher
  - e-PRC G.811.1 as future proposition
  - dual e-PRC even stricter bringing higher performance in terms of stability and phase quality
  - ePRTC A or B with tighter error budget over a shorter period?
  - Where to locate combiners, near on geo redundant like different region
  - Use of 10MHz low noise extenders to overcome budgetary restrictions
  - Coming of L1/L2 GPS dual band receiver enhancing performance of ePRTC-B
  - Build core step by step, ie adding more combiners over the years and start with one/two combiners?

- How to transport stable phase and frequency between regions?

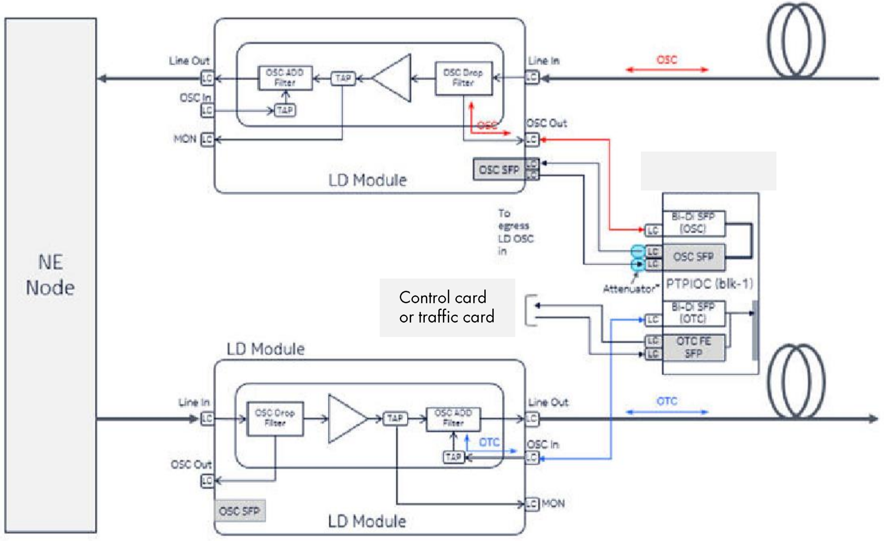
Transport of sync across domains

- Sync domains divided by regions
  - Regions divided into counties
- Phase+SyncE be delivered to all county centers
  - How to transport phase from the main HQ to regional HQ?



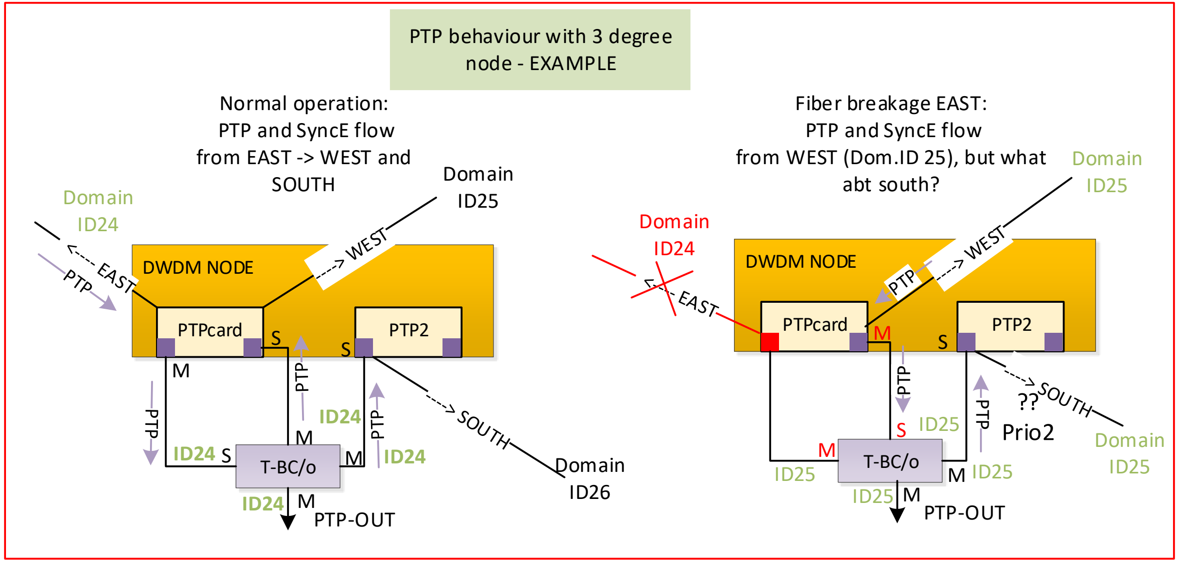
Transport of the phase and Sync E over DWDM

- Transporting phase sync over DWDM
- Usually DWDM nodes are compliant with ITU-T G.8275.1 PTP telecom profile or IEEE 1588v2
- ITU-T G.8273.2 T-BC /T-TSC Timing Characteristic is also supported
- These two characteristics could be supported in the same card or in separate cards
- Asymmetry compensation should be system based (inherent) or introducing new card that handles it
- signal conversion to bi-directional 1510nm wavelength over signal fiber



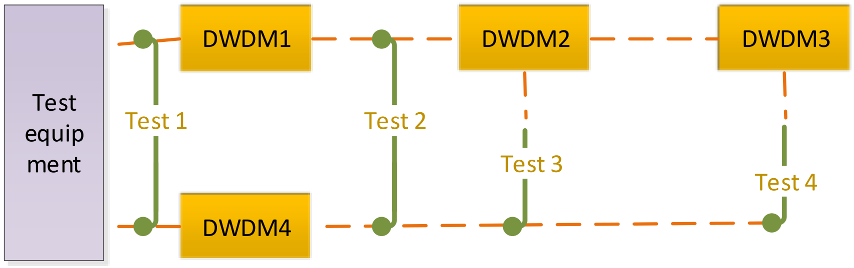
Transport of the phase and Sync E over DWDM

- The behaviour of T-TSC and T-BC in a chain of DWDM nodes
- What is the performance in case of T-TSC failure?
  - Routers connected to T-TSC get different time
- What is the performance in case of T-BC
  - Routers will not recover in parallel, but with time distance



Transport of the phase and Sync E over DWDM

- TE in the chain of DWDM nodes is hard to estimate
- Network elements act in relay mode where timing information from the OTC Line side of one module is relayed to the OTC Line side of another module



There is no definite relationship between the noise generation and the number of relay nodes!

Our strategy

- Full on path support (ITU-T G.8275.1 Telecom Profile)
  - Islands with managed Ethernet feature partial on path support, but in the core and the metro full on path support
- Everything in synchronisation network should be simple
- Use one PTP domain
- Separate ptp and synce source (no interplay between payload syncE and physical SyncE), hybrid mode
- Find a solution for resilience mechanism over long distances
- More PTP inputs

- Pair of combiners per country that are close (within 10-15km range).
- Future: increase Synce stability to 10-12

A1 Croatia in few (1,5) bullet

- 40% employees are women

- We are all in the some run towards all phase transport networks to fullfill future 5G (Well, I alone in my company)

Hvala!
Thank You!